LIVERPOOL

GEOLOGICAL ASSOCIATION.

TRANSACTIONS.

VOLUME VI.

SESSION 1885-6.

TWO SHILLINGS AND SIXPENCE.

LIVERPOOL

GEOLOGICAL ASSOCIATION.

TRANSACTIONS.

VOLUME VI.

SESSION 1885-6.

LIVERPOOL:
PUBLISHED BY HENRY YOUNG, 12, SOUTH CASTLE STREET.

1886.

INDEX.

—:o:—

The Authors are alone responsible for the facts and opinions expressed in their Papers.

—:o:—

Erratum.

Page 52, line 5, for "Zenorite," read "Tenorite."

LIVERPOOL

GEOLOGICAL ASSOCIATION.

ANNUAL REPORT,

1885.

LIVERPOOL GEOLOGICAL ASSOCIATION,

FREE LIBRARY, WILLIAM BROWN STREET, LIVERPOOL.

:o:

Council:

PRESIDENT:

HENRY BRAMALL, M. INST. C.E.

VICE-PRESIDENT.

CHARLES E. MILES.

MEMBERS OF COUNCIL.

I. E. GEORGE,	P. H. MARROW,
W. H. MILES,	H. T. MANNINGTON,

J. R. WEBB.

TREASURER.

T. R. CONNELL,
Melville Chambers, Lord Street, Liverpool.

SECRETARY.

D. CLAGUE,
81, Lime Grove, Liverpool.

The above form the Executive.

LIBRARIAN.

E. EVANS.

EDITOR.

W. H. MILES.

SUPERINTENDENT OF EXCURSIONS.

I. E. GEORGE.

Liverpool Geological Association.

ANNUAL REPORT,

SESSION 1884-5.

5th OCTOBER, 1885.

Another Session having passed, your Council have pleasure in presenting their Annual Report.

During the past Session 10 new members have been elected, and 2 members have resigned. There are at present on the roll 154 members.

During the Session nine Evening Meetings have been held, at which the following Papers were read and discussed:—

Address by the President on "Field Geology."

"Fossil Remains of Man," by J. R. Webb.

"Notes on a Recent Ascent of Mount Franklin, New Zealand," by D. Clague.

"Notes on Some Recent Additions to the Liverpool Museum," by F. Marrat.

"Ten Days in the Lake District," by H. Fox.

"Artistic Geology," by T. M. Reade, F.G.S.

"Mineral Crystals," by C. E. Miles.

"Rock Forming Minerals," by I. E. George.

"Notes on the Metalliferous Deposits of North America," by W. Semmons.

"On Silica," by G. Tate, Ph.D., F.G.S

The following FIELD MEETINGS have also been held:—

1885. 23rd May. Birkenhead and Tranmere. *Conducted by* Dr. Ricketts, F.G.S.

25th May. (Bank Holiday.) Windermere. *Conducted by* I. E. George.

15th June. Hilbre Island (with the Science Students Association). *Conducted by* A. Norman Tate, F.I.C.

11th July. Hightown. *Conducted by* I. E. George.

25th July. St. Helens. *Conducted by* Rev. S. Gasking, M.A., F.G.S.

3rd Aug. (Bank Holiday). Pontesbury. *Conducted by* I. E. George.

22nd Aug. Kirkby Moss. *Conducted by* I. E. George.

5th Sept. Thurstaston. *Conducted by* C. E. Miles.

On November 1st, 1884, a visit was made to the Royal Institution, Colquitt Street, to inspect the Collection of Minerals in the Museum there.

The Library, which has been closed for re-arrangement, is now open for the use of Members. Several additions have been made to it, and the thanks of the Association are due to Messrs. Bramall, Connell, Ellis, Evans, George, Hicks, Reade, and Wright, who have presented books.

During the past Session a fund for the purchase of Geological Maps was started, and Ramsay's Geological Map of Great Britain has been purchased. Thanks are due to the subscribers to that fund. A balance remains in hand, which it is hoped may be augmented by further subscriptions, as the Council consider that the Geological Ordnance Maps of the district would form a valuable addition to the Library.

The Association exchanges publications with the following Societies and Institutions:—

Belfast Naturalists' Field Club.
Burnley Literary and Philosophical Society.
Chester Society of Natural History.
Edinburgh Geological Society.
Geological and Natural History Survey of Canada.
Lancashire and Cheshire Entomological Society.

Liverpool Astronomical Society.
,, Engineering Society.
,, Free Library.
,, Geological Society.
,, Literary and Philosophical Society.
,, Naturalists' Field Club.
,, Philomathic Society.
,, Science Students' Association.
London Geologists' Association.
Manchester Geological Society.
Manchester Scientific Students' Association.
Mining Association and Institute of Cornwall.
Norwich Geological Society.
Royal Geological Society of Cornwall.
Smithsonian Institute, Washington, U.S.A.
Wagner Free Institute of Science, Philadelphia, U.S.A.
Yorkshire Philosophical Society.

Your Council regret the delay in the issue of the "Transactions," which for a time was unavoidable; the difficulties have now been surmounted, and the printing is being proceeded with as quickly as possible.

During the earlier months of the Session some difficulty was experienced in relation to the office of Honorary Secretary. The growing success of the Association has so increased the labours of the Secretary as to render it necessary that he should have assistance. Your Council, therefore, entrusted the duty of superintending the excursions to Mr. I. E. George, and that of editing the "Transactions" to Mr. W. H. Miles, and appointed Mr. D. Clague general Secretary. This division of the duties has so far worked well, and promises to meet the exigencies of the case; the retiring Council recommend it to be continued.

Your Council have arranged for a series of Saturday afternoon meetings at the Liverpool Museum during the winter, the first of which will take place on Saturday, October 17th, and be conducted by the Rev. H. H. Higgins, M.A.

The Council, while cordially acknowledging the co-operation and support they have received in the past, wish to point out how much may be done by individual members to make the Association still more successful, by supplying information as to suitable places to be visited,—by exhibiting at the meetings and describing interesting geological specimens,—by short communications of geological interest, and by preparing and reading papers.

The Treasurer's report, duly audited, is hereto appended. There remains a cash balance in hand of £11 16s. 5d., which, however, will be required to meet the cost of printing the "Transactions" of the Session, which are in arrear.

The Officers and Council for the ensuing year will have to be elected at this meeting, in accordance with Law III.

LIVERPOOL GEOLOGICAL ASSOCIATION in Account with the Treasurer.

FOR THE YEAR ENDING SEPTEMBER, 1885.

Disbursements.

Date		£	s.	d.
1885. September.	To Rent of Room	2	15	0
	,, Gratuity to Attendant for 2 years	1	0	0
	,, Printing and Stationery	11	5	0
	,, Postages and Incidentals	7	8	6
	,, Cash in Treasurer's hands	11	16	5
		£34	4	11

Receipts.

Date				£	s.	d.	£	s.	d.
1884. Sept.	By Balance brought forward						2	7	5
1885. Sept.	,, SUBSCRIPTIONS, viz. :—								
	146 Members at 5/-			36	10	0			
	4 Members paid in advance in previous years	£1 0 0							
	37 Members in arrears	9 5 0							
	41			10	5	0			
	105 Subscriptions for year 1884-5			26	5	0			
	1 Subscription for 1882-3.			0	5	0			
	9 ,, 1883-4.			2	5	0			
	9 ,, 1885-6.			2	5	0			
	124						31	0	0
	,, Receipts from Members for Printing						0	17	6
							£34	4	11
	By Balance brought down						11	16	5
	LIBRARY FUND.								
	Donations received			£2	0	0			
	Paid for Map			1	13	6			
							0	6	6

Audited and found correct,

(Signed) THOS. R. CONNELL, W. H. MILES, } AUDITORS.

Liverpool, 23rd September, 1885.

W. H. WALKER,
TREASURER.

LAWS

OF THE

Liverpool Geological Association,

ESTABLISHED 3rd JUNE, 1880.

RULES PASSED 15th NOVEMBER, 1880.

OBJECT.

The object of the LIVERPOOL GEOLOGICAL ASSOCIATION is to promote the study of Geology and its allied Sciences.

RULES.

I.

That every Candidate for Membership shall be proposed and seconded by two members of the Association, and balloted for at the next Ordinary Meeting; and the consent of three-fourths of the members then present shall be necessary for the admission of such Candidate.

The proposal shall be made on Form A, which must be filled up and lodged with the Secretary one week before the meeting at which the Candidate is to be proposed. The proposal form shall be submitted to the Council, and the Secretary shall report to the Members any remarks the Council may deem it expedient to make thereon.

II.

Every Member shall pay an annual subscription of Five Shillings, payable on the 1st October, or, in the case of a new member, within one month after election. Any member not paying the subscription within three calendar months, after being twice informed by the Secretary that it is due, shall no longer be considered a member of the Association.

III.

The Officers of the Association shall be a President, Vice-President, Treasurer, Secretary, and five other members, who together shall constitute the Council to manage and direct the affairs of the Association. Five to form a quorum. The officers shall be elected at the Annual Meeting to be held in October; retiring officers shall be eligibe for re-election. Any vacancy occurring during the year shall be filled up by the Council.

IV.

The Treasurer's Financial Statement shall be presented to the Association, with the Annual Report, after having been duly audited by two members proposed, seconded, and elected at the last meeting of the Session.

V.

The Ordinary Meetings shall be held on the first Monday in each month, at eight o'clock in the evening. The order of proceeding at such meeting shall be :—

1.—The ordinary business of the Association.

2.—Miscellaneous Communications.

3.—Original Papers or Communications, to be followed by discussion thereon.

4.—Announcement of business for the next Meeting.

VI.

A Special Meeting may be called at any time by the Council; and they shall be bound to call such a meeting on receipt of a requisition signed by not less than ten members, stating the purpose for which the meeting is to be convened. Seven days' notice of a Special Meeting shall be given to every member, such notice to specify the business to be considered; and the meeting shall be held within twenty-one days after the receipt of the requisition. No other business shall be considered at a Special Meeting, except that for which it has been called.

VII.

Field Meetings shall be held at places of geological interest, but none of the private business of the Association shall be transacted on such occasions.

VIII.

The votes on any question brought before the Association shall be taken by a show of hands, except those for the election of officers and new members, which shall be taken by ballot.

IX.

The manuscript of every Paper read, or a clear and legible copy thereof, written on foolscap, shall become the property of the Association, and shall be placed in the Library for the use of the members.

X.

In case of non-compliance with the Rules of the Association, or misconduct by any member, such member may be requested by the Council to resign. Failing to do so, the Council may bring the case before a meeting of the Association which shall deal with it as may seem expedient.

XI.

Every member may introduce a friend at any Ordinary or Field Meeting of the Association, provided, however, that no person qualified to become a member be admitted as a Visitor more than twice in the same year.

XII.

No addition to, or change in these Rules shall be made except by a majority of not less than two-thirds of the members present at a Special Meeting to be convened for that purpose.

LIVERPOOL GEOLOGICAL ASSOCIATION.

FORM A.

M..

....

being desirous of admission to the Association, We, the undersigned, recommend h as a proper person to become a Member.

Dated..................18

Proposed by..

Seconded by..

Date Proposed..

Date Elected...

Signature of Candidate...............................

..................................Secretary.

REGULATIONS FOR THE ADMISSION OF MEMBERS.

Rule 1.—That every Candidate for membership shall be proposed and seconded by two members of the Association, and balloted for at the next ordinary meeting; and the consent of three-fourths of the members then present shall be necessary for the admission of such Candidate.

The Proposal shall be made on Form A, which must be filled up and lodged with the Secretary one week before the meeting at which the Candidate is to be proposed. The proposal form shall be submitted to the Council, and the Secretary shall report to the members any remarks the Council may deem it expedient to make thereon.

Rule 2.—Every Member shall pay an annual Subscription of Five Shillings, payable on the 1st October, or, in the case of a new member, within one month after election. Any member not paying the subscription within three calendar months, after being twice informed by the Secretary that it is due, shall no longer be considered a member of the Association.

LIVERPOOL GEOLOGICAL ASSOCIATION.

LIST OF MEMBERS,

Session, 1884-5.

Ashton, F. W....	4, Richmond-terrace, Breck-road.
Auden, Anthony W.	137, Northbrook-street.
Bramall, Henry, M. Inst. C.E., (President)	Gilmour House, Falkland-road, Egremont.
Banister, H. C.	Rossett-road, Crosby.
Barber, J. M.	4, Eyes-street, Breckfield-road North.
Baylis, J. Walter	56, Vine-street.
Beasley, H. C.	Leam Cottage, Wavertree.
Bellamy, C. R.	Cecil Villa, Victoria Park, Walton.
Brennan, Thomas	30, Granton-road.
Biram, Benj., Assoc.M. Inst. C.E.	St. Helens, Lancashire.
Biram, B. Swinton, B.A.	Sherdley, St. Helens.
Broadfoot, Bruce M.	67, Huskisson-street.
Brodie, Alexander	202, Upper Parliament-street.
Brodie, J. S., M.I.M.E.	Borough Engineer, Whitehaven.
Brown, Jos.	37, Exe-street.
Browne, A. H.	31, James-street.
Cade, Lawrence W.	15, Upper Parliament-street.
Capon, R. M., L.D.S.	114, Vine-street.
Carter, C. W.	4, Springfield, Everton.
Clague, Daniel (Secretary)	81, Lime-grove, Lodge-lane.
Clarke, F. C.	47, Bickerton-street.
Conlon, Bernard	22, Mount-pleasant.
Connell, T. R. (Treasurer)	Melville Chambers, Lord-street.
Cooper, W. R., B.A.	11, Northumberland-terrace, Everton.
Cotter, Mrs. B.	10, Oxford-road, Waterloo.
Crate, H. L	Bromboro' Pool.
Currie, Luke	3, Lord-street.

Davies, David	Care of Messrs. Cochran & Co., Woodside Iron Works, Dudley.
Defieux, C.	98, Herschell-street.
Deuchar, P. B.	17, Kingsley-road.
Dickson, Edmund	30, Eastbourne-road West, Birkdale.
Downie, George	19, Oakfield-street.
Duff, Samuel	55, St. Martin's Cottage, Ashfield-street.
Dudley, A. H.	33, Gibson-street.
Dunsford, A. J.	Wynch House, Seacombe, Cheshire.
Edwards, F. W.	Fairhope, Victoria Park, Walton.
Evans, E. (Librarian)	35, Beresford-road, Toxteth Park.
Evans, J. C.	37, Ranelagh-street.
Evans, J. G.	Brunswick Dock.
Elias, O. H	Mere House, Mere-lane, Everton.
Frazer, John	1, Railway Cottages, Spekeland-road.
Findlow, John	42, Percy-street.
Finlay, R. F.	Slater-court, Castle-street.
Fowler, Thomas Richard	139, Crown-street.
Fox, Herbert	18, Hackin's-hey.
Gasking, Rev. Samuel, B.A., F.G.S.	West View, Cowley-hill, St. Helens.
Gray, G. Watson	12, Argyle-road, Garston.
George, Isaac E. (Member of Council) (Superintendent of Excursions).	89, Beaconsfield-street.
Gregson, G. E.	11, Chapel-street, Preston.
Grisewood, W.	Liscard Park, Liscard, Cheshire.
Hall, Henry, H.M. Inspector of Mines	Rainhill.
Hall, Hugh F., F.G.S.	Greenheys, Grove-road, Wallasey, Cheshire.
Hancox, John	101, Prescot-street.
Hedley, J. L., H.M. Inspector of Mines	The Gables, Flooker's Brook, Chester.
Henson, Samuel	227, Strand, London, W.C.
Hewitt, William, B.Sc.	21, Verulam-street.
Hills, William	Fountain-street, Higher Tranmere Cheshire.
Holbrook, The Hon. Henry	Parkgate, near Chester.
Houlding, John	34, Tynemouth-street.
Hunt, T. S.	140, Allerton-road, Woolton.
Jeffs, Osmund W.	8, Queen's-road, Rock Ferry.
Johnson, T. M.	5, Byrom-street.
Johnston, W. H.	11, Chapel-street, Preston.

Jones, J. C.	82, Windsor-street.
Jones, R. T.	32, Canning-street.
Jones, W. A.	32, Laurel-road, Edge-lane.
Jones, W. Joinson	7, Rhiwlas-street.
Keyte, T. S., C.E.	9, Chatham-place.
Kirkmann, H.	Oswell Bank, Seaview-road, Liscard, Cheshire.
Kissack, J. M.	18, Newland-street, Everton.
Labouchere, J. M.	106, Spencer-street.
Lawrenson, F. J.	131, Walton Village, Walton.
Lewis, A. E.	74, Rogerson's Quay, Dublin.
Lister, R. F.	8, Ashfield, Wavertree.
Littlewood, T.	40, High-street, Woolton.
Logeman, Willem S., Lit Hum. Cand., M.R.C.P.	Newton School, Rock Ferry, Cheshire.
Maguire, T.	108, Landseer-road.
Mannington, C. E.	40, Rumney-road, Kirkdale.
Mannington, H. T. (Mem. of Council)	60, Rawcliff-road, Walton.
Marrat, Frederick P.	21, Kinglake-street.
Marrow, Fred.	
Marrow, P. H. (Mem. of Council).	31, Bell-road, Seacombe.
Martin, William	14, Normanby-street.
Miles, Charles E. (Vice-President).	57, Willow Bank-road, Higher Tranmere, Cheshire.
Miles, W. H. (Member of Council) (Editor)	41, Whetstone-lane, Birkenhead.
Moore, Miss Emily	1, Sheen-road, Sea Bank-road, Liscard.
Moore, T. J., C.M.Z.S	The Museum, William Brown-street.
Morgan, C. H.	72, Bank-road, Bootle.
Morgan, James	City Engineer's Office, Dale-street.
Morris, John	40, Wellesley-road.
Morris, Mrs. John	40, Wellesley-road.
Narramore, W.	5, Geneva-road, Elm Park.
New, R. G.	49, North John-street.
Nicholls, John	11, Chatham-place.
Owen, William	4, Comus-street.
Owens, Philip	66, Orient-street.
Padley, F.	15, Church-street.
Pain, C. Squarey	14, North John-street.
Paton, Rev. Wm., M.A.	Mossgiel House, New Ferry, Cheshire.
Potter, Charles	101, Miles-street.

Plastow, James	169, Great Homer-street.
Pratt, Miss E.	15, Alt-street.
Pritchard, D. D	10, Lothair-road, Anfield.
Quilliam, W. H.	49, Rufford-road.
Reade, T. Mellard, C.E., F.G.S, F.R.I.B.A.	Park Corner, Blundellsands, Lancashire.
Ricketts, Charles, M.D., F.G.S	22, Argyle-street, Birkenhead.
Roberts, Isaac, F.G.S.	Kennessee, Maghull.
Roberts, J. Meredydd	Cawdor-street.
Roberts, Robert	9, Northumberland-terrace.
Robins, G. J.	Ashton Cross, Newton-le-Willows.
Robson, Herbert, B.Sc.	Bootle College, Breeze-hill.
Robson, George	66, Roscoe-street.
Robson, Mrs.	17, Nile-street.
Ross, Alexander, M.Inst. C.E.	L. & N. W. Railway, Edge-hill.
Rowe, Edmund	23, Frodsham-street, Tranmere, Cheshire.
Rowett, Charles	2, Verulam-street.
Rowlands, T. V.	89, Duke-street.
Rundell, T. W.	Litherland Park.
Schweitzer, W.	2, Ashfield, Wavertree.
Sharpe, R. A.	5, Welbeck-terrace, Birkdale, Southport.
Small, Laurence	39, Enid-street.
Shilston, Capt. H. P.	1, Saltoun-terrace, Seacombe.
Shilston, Mrs. H. P.	1, Saltoun-terrace, Seacombe.
Shilston, Thomas, M.I.N.A.	31, Westmoreland-road, Newcastle-on-Tyne.
Shilston, Mrs. Thomas	31, Westmoreland-road, Newcastle-on-Tyne.
Simpson, L. C.	Falkland-road, Egremont, Cheshire.
Smith, Edward	15, Upper Parliament-street.
Storey, John	27, Gibson-street.
Tapscott, R. L.	41, Parkfield-road.
Tate, A. Norman, F.I.C.	9, Hackins-hey.
Tate, George, Ph. D., F.G.S.	College of Chemistry, 96, Duke-street.
Tate, John A.	27, Chestnut-grove, Marsh-lane.
Tildesley, H. F.	78, Woodville-terrace, Everton.
Thomas, Hopkin	4, Cable-street.
Walker, William H.	40, Castle-street.
Walsh, Peter H., F.C.S	Stafford.

Ward, Thomas	Northwich, Cheshire.
Webb, John R. (Member of Council)	29, Fountain-street, Higher Tranmere.
Westcott, H.	94, Prince's-road.
Wigzell, Miss M.	22, Russian-drive, Tue Brook.
Wilding, James	92, Troughton-street.
Williams, J. J.	3, Ducie-street.
Williams, J. M.	The Hawthorns, Hawthorn-road, Bootle.
Williams, Miss L.	55, Rocky-lane, Anfield.
Williams, T. G.	Moss Bank, Croxteth-road.
Williams, T. H.	2, Chapel-walks.
Wright, W.	86, Hulton-street, Moss Side, Manchester.
Young, Henry.	12, South Castle-street.

Abstract of Proceedings

OF THE

LIVERPOOL GEOLOGICAL ASSOCIATION.

SESSION 1885-6.

OCTOBER 5TH, 1885.

The Annual Meeting was held on this date at the Free Library—Mr. H. BRAMALL, M. Inst. C.E., President, in the chair.

Mr. James Wilding was elected a member.

DONATIONS.

Proceedings of the Liverpool Geological Society, vol. V., part 1; Transactions of the Edinburgh Geological Society, vol. IV., part 3; vol. V., part 1; Report and Proceedings of the Manchester Science Students' Association for 1884; Proceedings of the Liverpool Philomathic Society, vol. XXX., 1884-5. *Presented by the respective Societies.*

The Annual Report and Treasurer's Statement of Accounts were presented, and adopted by the meeting; and the Officers and Council for the ensuing Session were elected—(*for List, see page* 2.)

The following objects of interest were exhibited during the meeting:—Silicious Minerals, exhibited by Mr. T. D. Howard; Metallic Minerals, by Mr. T. S. Keyte; Fossil Footprints, by Mr. W. H. Miles; Stem of Free Fern, by Mr. R. W. Manning; Chalk Fossils, by Mr. C. Potter; Microscopes and Slides, by Miss Williams, Messrs. George, Padley,

and Conlan; Photographic Views of Swiss Scenery and Album of Alpine Plants, by Mr. Padley; Scientific Books and Plates, by Mr. H. Robson.

OCTOBER 17TH, 1885.

A Meeting for the Practical Study of Paleontology was held this day at the Museum, William Brown Street—the Fossil and recent Cephalopoda being selected for study, under the guidance of the Rev. H. H. HIGGINS, M.A.

NOVEMBER 2ND, 1885.

At the Ordinary Meeting held this date at the Free Library—Mr. H. BRAMALL, M. Inst. C.E., President, in the chair.

DONATION.

Proceedings of the Chester Society of Natural Science, No. 3. *Presented by the Society.*

A Paper was read by Mr. P. H. MARROW, on

"TRIASSIC SANDSTONES OF WEST CHESHIRE,"

of which the following is an abstract.

IF we could see the whole of the trias of West Cheshire in one section, we should probably find the lowest beds composed of a soft, red sandstone, overlaid by a bed of sandstone containing quartz-pebbles, next a sandstone without quartz-pebbles, or practically so. Slightly unconformable on these, we should first have a pebble-bed—but the pebbles are mostly composed of clay—then a sandstone without pebbles. Now, this information throws no light upon the origin of the trias; and, for the necessary information, the geologist will have to go further west and start at the older end of the geological scale; and, as we travel westward, we find that the character of the trias is changing in mineral composition: it is no longer a quartz sandstone, but a very composite rock,

composed of grains of quartz, felspar, diorite, &c. At Hilbre Island we find the clue that will probably lead to the information necessary to account for the trias rocks of the district in a very remarkable pebble-bed, very unlike the pebble-beds further east, for it contains angular fragments of sandstone, indurated clays, quartz, &c., embedded in a matrix of clay; and this pebble-bed tails off into a fine clay. Here, then, is where the littoral zone commenced for the West Cheshire sandstones. We hear geologists say that the trias of America or of Russia is like our Cheshire type. I presume they mean to say that it is a sandstone. If they mean that the Russian trias agrees in mineralogical composition with the Cheshire stone, I am afraid that they are mistaken. It is no more like than one sandstone is like unto another laid down under similar conditions. Our trias rocks are purely local, and the Cheshire rocks came from S.W. Wales. They bear the stamp of the Welsh deposits only in the reverse order.

In looking over the Welsh rocks, we find permian, carboniferous, old red, and silurian represented; and these deposits are fearfully denuded. The sandstones of Cheshire represent the denudation in part of these old palæozoic rocks in the triassic period. If this is so, we should expect to find the mineralogical characters to agree somewhat with the Welsh primary rocks. In the lowest bed of the Bunter sandstone, the grains that go to compose the rock are very much rounded; so much so, as to lead to the idea that they may have been laid down more than once as a sandstone. The stone is less mixed in composition than the newer members of the group, and approaches to what may be called a quartz sandstone, and probably represents the denudation of the permian rocks. This re-deposition of the palæozoic rocks is represented in all its characters—even to the upper members of the trias, where we have great quantities of clay, probably representing and bearing the mineral characters of the silurian silicates. The conditions under which the new red sandstones of Cheshire were laid down speak of shallow

water, probably in lakes or an inland sea, nowhere do we find evidences of deep water conditions. On every side the facts point the other way—to a low-lying valley that was gradually sinking. Our trias rocks were probably deposited in a palæozoic inland sea, which received the rivers with their sediments from the mainland on all sides. In looking over the trias rocks of this interesting district, beautiful examples of current bedding are constantly met with. Many sections of the sandstone are strangely marked, and almost lead to the suspicion that great accumulations of blown sand were laid out (owing to the subsidence of the land) in moderately still waters. This may be studied to great advantage in a section running through Wallasey, and exposed on the roadside beneath Wallasey Church. There we have an incoherent bed of sand capped by a compact sandstone. The underlying bed is strangely marked and contorted, and, I believe, has led some to think that the contortions are due to pressure from ice; but, when examined, the sandstone is found to be composed of very minute, beautifully-rounded grains. No signs of pebbles or coarser materials are met with. It has all the characteristics of blown sand; the strange contortion-like markings it probably owes to its mode of deposition. Leaving the Cheshire side of the Dee, and crossing to the Welsh coast, the geologist is at once struck with the rounded forms of the hills, the number of valleys formed through anti-clinal curves, and the general character of the denudation. He will also have his attention called to the remains of volcanic action which has at various times been very active there; further, he will observe that nearly all the metals (especially in the older formations) are sulphides, which sulphides are probably due to volcanic agencies in the past. He further notices that the valleys and sides of the hills are denuded across these mineral deposits, and, if given to calculating, he will try to estimate the amount of mineral wealth that has been removed by denudation and carried to the sea. Now, it is with this metallic matter that was denuded in the triassic period that

we have to deal. The rivers and streams that carried down the sediment for the trias deposits likely also carried a great amount of the metals or salts of the metals in solution (probably as carbonates). We have already seen that the metals contained in the Welsh palæozoic rocks are mostly sulphides. The colouring matter of the trias sandstones is oxide of iron, the iron of which has probably been derived from the weathering of the sulphides of the metal—ferrous sulphate being produced by such decomposition; but, in the presence of carbonates, this sulphate is decomposed—the acid being taken up by the alkaline earth or alkali, and the iron becoming a ferrous carbonate, which carbonate rapidly oxidizes and falls, as the familiar yellow or brown crust of hydrous peroxide. Now, it was through this oxide of iron being precipitated in moderately still waters that gave the colour to the trias sandstones. That it was under some such conditions of deposition is very forcibly felt when examining the sandstones of the neighbourhood. Each and every grain of sand composing the rocks is found to be coated with this oxide of iron (*i.e.*, the red and yellow varieties). In many of the red examples the iron acts as a binary substance, each grain of sand being cemented together by the oxide. But, in some of the lighter coloured members of the group, the iron does not appear to play such an important part. These lighter coloured beds, probably representing the denudation of the older palæozoic rocks, contain, or did at one time contain, large quantities of felspar; hence the binary substance is in some cases purely silicious, the silicious cement being derived from the decomposition of the felspar. In the sandstones of this character very beautiful crystals of quartz are sometimes found, the crystals ranging from one-fourth to one-half an inch in length, the whole of the rock being in many cases of a perfectly crystalline character. The decomposition of the felspar and crystallizing out of the quartz is of a later date than the deposition of the sediment, and has in all probability been brought about by organic agencies.

In comparing the various sandstones one with another, the greatest diversity of character is seen, more especially as to texture, colour, and binary substances; and on comparing the sandstones that are covered with the keuper marls or with the boulder clays, with those covered by peat mosses or surface soils, the former are usually red, whilst the latter are either white or variegated. This diversity of colour is owing to the agencies now at work. The iron, as diffused in the rocks, exists in combination with oxygen, with which it forms two principal compounds—the first, or protoxide, which is readily soluble in waters impregnated with carbonic acid; and the second, or peroxide, which is insoluble in the same liquids. The combinations of the first oxide are either colourless, bluish, or greenish in tint, while the peroxide is reddish-brown. Many of the lighter coloured sandstones contain very little iron as compared with the red varieties of the group; but there is little doubt that at one time they were equally as ferruginous. They have since lost their iron by a process everywhere going on around us—viz., organic agencies, as decaying vegetation, &c.

From what has been said, it is easy to conclude that colour is no test as to age in the trias rocks, colour being only accidental. The intervention of a peat-bed, or any decaying vegetable matter, may cause a red variety to become yellow, mottled, or even white.

LIVERPOOL GEOLOGICAL ASSOCIATION.

NOVEMBER 14TH, 1885.

The second visit of the season was made to the Museum, William Brown Street, when a comparative study of the Bones of the Hand of the higher classes of Vertebrata was made under the direction of Mr. A. W. Auden.

DECEMBER 7TH, 1885.

Ordinary Meeting, held this date at the Free Library, Mr. H. BRAMALL, M. Inst. C.E., President, in the chair.

DONATIONS.

Phenological Stations, by M. A. Ramsey, *presented by the author;* Annual Report of the Smithsonian Institution, Washington, U.S.A., for 1883, *presented by the Institution;* Report of the Liverpool Science Students' Association, 1884-5; Proceedings of the Geologists' Association of London, vol. 8, Index, vol. 9, No. 3; Transactions of Manchester Geological Society, vol. 18, part 2—*presented by the respective societies.*

EXHIBITS.

Mr. W. H. Miles exhibited some clay nodules, showing colour banding, from a cutting recently made in Bidston Hill. Mr. C. Potter exhibited a number of specimens of sand from the sandhills, Wallasey coast, showing variations in colour and texture similar to those in the Trias sandstones.

A Lecture was given by Mr. C. POTTER, of which the following is an abstract, on

THE GEOLOGY OF THE SOUTH EAST OF ENGLAND,

ILLUSTRATED BY MINERALS AND FOSSILS FROM THE DISTRICT.

The geology of Sussex may be taken as representing that of the south east of England in its principal groups—the Eocene, upper and lower Cretaceous, and the gravels, with what are known in this neighbourhood as the post-glacial, to be found in the river valleys and their embouchures. Brighton is situated on the chalk of the South Downs, which extends eastward to Beachy Head and Eastbourne, and westward into Hampshire.

The visitor to Brighton would do well in the summer to take a seat in one of the many conveyances which start from West Street for the Devil's Dyke, if he has not had an opportunity of seeing the varied character of the country as represented in its geological formations.

On arriving at the scarp of the Downs overlooking the Wealden, a landscape opens out in striking contrast to that by which he has travelled from Brighton. Immediately below him the Upper and Lower Greensands, with the intermediate Gault, crop out, and to the northward the Wealden beds, producing a forest growth unsurpassed in this country.

The character of the Wealden Beds varies from a friable sandstone to hard calciferous sandstone and conglomerate, interspersed with clays, shales, and a limestone which is known in the district as the "blues." Some parts of the Weald are also rich in ironstone, which from a very early period was worked in Sussex; the greater part of the iron industries of the country being monopolised by Sussex until the close of the 17th century. The iron made in this county was wood smelted and of fine quality. The chief cause of the decay of this great industry was the destruction of the woods for smelting purposes, and the opening up of iron works, in which coal took

the place of wood for smelting. Mr. Godwin-Austen having brought to the notice of geologists in this country the probability of finding palæozoic rocks immediately underlying the Wealden, as in Belgium and the north of France, the subject was taken up by Henry Willett, Esq., F.G.S., of Brighton, who suggested that a boring should be made.

The boring, commenced in August, 1872, was carried by the first conductor, Mr. Bosworth, to the depth of 312 feet, it was then taken up by the Rock-boring Company, of which Col. Beaumont was chairman, who continued it to the depth of 1018 feet, when, an accident occurring, the work had to be stopped, and commenced afresh in February, 1875, this time being sunk to 1905 feet, when another accident put a stop to it.

The sinking passed through about 200 feet of Purbecks, 60 feet of Portland, and 1650 feet of Kimmeridge clay and coralline beds. The lowest cores brought up were supposed to represent the Oxford clay.

It is to be hoped that further borings may be made, as it is probable that the vast thickness of Kimmeridge clay passed through was the accumulated deposit in a deep valley of the older rocks.

The name Greensand may mislead those who have not examined the formation in different localities, as while the prevailing colour is green, the same as the Triassics are red, yet the colour varies as much in the one formation as in the other. The Gault formation, which separates the upper from the lower Greensand, consists of dark-blue calcareous clays, and is very rich in the casts of marine chambered shells. The impervious Weald clays below the Greensand formation make the latter a vast reservoir for the water, rain falling on the surface, and rapidly percolating the chalk. An idea may be formed of the water storage in this basin, from the height to which it rose in a well sunk by the Brighton Guardians, for the supply of an Industrial School at the Warren Farm, to the east of Brighton on the Downs; it was commenced at an elevation of 421 feet above low water datum, and sunk

to the depth of 1285 feet, when the Gault was penetrated and the Lower Greensand reached, with the result that the water rushed in and rose in the well until it stood 60 feet above low water mark.

The character of chalk, as a soft white amorphous carbonate of lime, is well known to most. It is divided into two distinctly marked groups, viz., the Upper Chalk with flints, the Lower without, the latter being of a darker colour than the former. Both chalks are very rich in marine fossils of great variety, and in the finest state of preservation. The univalves, unless preserved in sulphuret of iron, are seldom if ever found, except as casts, the shells themselves having dissolved after the interior had filled, and the ooze filling had hardened into chalk, whilst bivalves, radiata, crustacea, &c., have their shells in perfect preservation; this, it would appear, arises from the shell of the univalve being formed of arragonite, whilst the others are of calcite. — See Anniversary Address of the President (H. C. Sorby, F.R.S.), Geological Society of London, No. 138, 1879.

Between Brighton and Eastbourne, except in the river valleys of the Ouse and Cuckmere, may be seen very fine sections of the chalk with flints. The horizontal beds of flints, running parallel with each other in the long line of cliffs on this coast, show no signs of lateral pressure. Evidence of considerable upheaval and depression is to be found of the chalk in the neighbourhood of Lewes. About a mile from that town the Hastings line of railway crosses the river Ouse, and immediately enters a cutting through the lower or grey chalk; this is evidently an upthrow, as is finely illustrated in the large chalk pit close by, where the white chalk with flints dips at an angle of about 20 degrees towards the north, whilst at another large pit about half a mile nearer to Lewes, the flint stratification is horizontal. On the surface or top of the hill no trace can be seen of what must have been a deep valley, subsequently filled up with a similar chalk formation, but in the hill scarp which extends between the two pits the

line of juncture or dip of the old valley and the subsequent deposit in it may be traced. From the Southerham pit, looking across the valley of the river Ouse to the hills on the southern side, may be seen about midway what is locally and very aptly called a Rise; and a short distance lower down the river valley is a second and smaller, both rising like immense bosses from out of the meadow land by which they are surrounded; and as both are of the Upper Chalk, they would appear to indicate a down-throw.

The rounded surface of the Downs, with the deep valleys or combes, the crushed and broken flints accumulated in hollows or pockets in the chalk below the surface soil, from which they are dug for road metal, would all indicate that ice has played no small part in gouging out the valleys, and in shaping and smoothing the surfaces.

The Tertiary formations are largely exposed along the coast of Sussex, but the most interesting field for research, and one which will produce the richest harvest to the collector, is to be found near Selsey, about eight or ten miles south of Chichester. Here, tide and sand permitting, the fossil collector may revel in the Eocene formation, known as the Bracklesham Beds.

He will there find the most beautiful and varied marine fauna beneath his feet, forming a more beautiful tesselated pavement than art ever produced.

On this shore, the yellow drift clay, with its erratic boulders of the earlier rocks, including the granites, is well exposed; very interesting amongst these erratics are the many huge blocks of a grey sandstone similar to those of Stone Henge, and as large as the largest there. Blocks of this sandstone of much smaller size are to be found distributed over the Downs; they appear to be mostly rounded by attrition, and are known locally as "grey wethers," the name being derived from their resemblance to a reclining sheep when viewed from a distance. At low tides what is known as a sub-merged forest may be seen, but one would suppose few could be found who, after

having examined the formation and its contained arboral remains, would support the theory of growth-in-situ; it is a vast accummulation of tree trunks which would, in a fresh state, gladden the heart of a dealer in British timber. Not an attached bough or root is to be seen, neither are there any roots or stools amongst this mass of drifted timber, the whole being imbedded in a matrix of very dark silt, the dark colour being derived from decayed vegetable matter. A few tree stools, with roots imbedded in the clay, are to be seen in a different and higher formation; amongst these was one stool six inches in diameter, with outspread imbedded roots, the stool itself, about a foot in length, being downward in the undisturbed matrix.

In the low cliff bounding the shore is to be seen a bed of flints, the white covering peculiar to flints taken direct from the chalk being still retained with the edges of fracture sharp and perfect. The nearest chalk is some six or eight miles distant.

The gravel and clay tertiaries extend from Selsey north to Chichester, where the Chalk Downs are reached, and stretch eastward to Brighton; here the chalk again abuts upon the shore. It is overlain by an ancient flint shingle, eastward from Brighton. A good section of this bed may be seen above the chalk, which rises and forms the sea cliff, above this lifted ancient beach is a formation known as the Elephant Bed, from the numerous teeth and bones of that animal found in it; it is a dark rubbly loam, and must be from 100 to 150 feet in thickness.

At Newhaven, the chalk is overlain in descending order by the London clay, Woolwich and Reading beds.

Immediately below this hill is the town and harbour of Newhaven, at the mouth of the river Ouse. Crossing the latter to where the chalk again rises, we come upon tertiaries overlying the lower part, or foot of the hill; in the face of the low cliff it may be seen filling "pipe" holes in the chalk. Beyond Seaford, the chalk cliffs rise to a great height, extending some

two miles to the valley of Cuckmere, through which the river bearing that name flows. Rising on the opposite side of this narrow valley, the white cliffs, with their horizontal beds of flint, stretch westward, until their greatest altitude is reached at Beachy Head; from this the hill descends by the Wish Tower to Eastbourne. On the shore beneath the Wish Tower, the Lower or Grey Chalk crops out with the Greensand and gault as you proceed eastward, but these are for the most part shut out from view, and soon entirely lost under the shingle, as are the Post Pliocene deposits of Pevensey Marsh and Bay. The Marsh, corresponding with that of Romney on the northern side of the Wealden anticlinal, reaches almost to Hastings; there the Wealden formation rises, with its varied formations of sands, sandstones, limestone, clays, and the underlying Purbecks. The weathering and crosion of the softer beds has given rise to the numerous glens and valleys intersecting this country, which, with their rich and varied flora, give a charming beauty to the landscape of this district. In many of the old watercourses the fossil collector may reap a rich harvest from the different exposed sections of the Wealdens.

On the littoral before reaching St. Leonard's, and from there past Hastings, very interesting Wealden stratification is exposed, whilst a section, known as the Hastings sands, on the grandest scale, is to be seen in the long range of cliffs bounding the shore.

The tract inland from Pevensey Bay, known as the Pevensey Levels or Marsh, is intersected by the clays and sands of the Weald, in the valleys and hollows of which are the alluvial deposits and other formations. Typically of the River valley strata of this country are to be found in this Marsh, the upper and lower peats (so-called submerged forest), with the intersecting deposits of estuarine silt (scrobicularia clay), sections of which are so well exposed on the Cheshire and other shores of this district.

To those who wish to study the Geology of the South East of England, the writings of the late Dr. Mantell, Mr. Wm.

Topley, of the Ordnance Survey, and the "Geology of Sussex" by the late Fredk. Dixon, Esq., especially the last edition, edited by T. Rupert Jones, F.R.S., are recommended. In Brighton, the Willett collection in the public Museum should be visited, it will be found alike interesting and instructive to the student, the scientist, and the man of cultivated taste.

LIVERPOOL GEOLOGICAL ASSOCIATION.

DECEMBER 12TH, 1885.

The third visit to the Museum, William Brown Street, was made this day, when an Address on Corals and Zoophites was given by Mr. P. H. Marrow.

JANUARY 4TH, 1886.

At the Ordinary Meeting, held this date at the Free Library, Mr. H. T. MANNINGTON in the chair, Mr. C. F. Webb, 46, Wellington Terrace, was proposed for membership.

DONATIONS.

Third Annual Report of the Free Library, Barrow-in-Furness, 1884-5, and Catalogue of Books, *presented by Mr. J. Froude, Chief Librarian;* Papers "On some Erratics in the Boulder Clay of Cheshire, &c.," and "On Indented Pebbles in the Bunter Sandstone near Prescot," by Charles Ricketts, M.D., F.G.S., *presented by the Author;* Transactions of the Leeds Geological Association, part 1, 1883-5, *presented by the Association.*

EXHIBITS.

A case of Silica Minerals exhibited by Mr. F. P. Marrat; internal cast of Calamite from the pebble beds, by Mr. J. M. Barber; footprints of young Rhyncosaurus, from Storeton, by Mr. D. Clague; and a slab of markings, supposed to be Cheirotherium footprints, from Kirkdale, by Mr. I. E. George.

An Address was given by Mr. T. BRENNAN, on

FOSSIL REPTILES.

The earliest description of a fossil reptile is, I believe, that of Spener, who, in 1710, pointed out the crocodilian characters of the Protorosaurus from the Permian rocks of Thuringia. Since that time there have been many enthusiastic workers in the field, among whom our veteran palæontologist, Owen, stands pre-eminent. On the American Continent, Marsh and many others are bringing to light, from the jurassic and cretaceous rocks, many strange forms.

The classification of the class Reptilia is a matter of such difficulty that I shall not attempt it, but use the best known forms to illustrate the affinities the various groups bear to each other.

If we include the amphibians we find the earliest traces of the class at the base of the coal measures, the best known genus being the Archegosaurus, which has some characters in common with the older ganoid fishes, some specimens having been referred, even by Agassiz, to that class. The head was defended by bony ganoid plates, including two, the post orbital and supra temporal, which are found in salamandroid fishes. Like the old ganoids the notochord was persistent, or, in other words, the bases of the vertebræ remained throughout life in a cartilaginous sheath. The remains of the arches which supported the gills, and the absence of occipital condyles, show them to be related to the reptiles like the proteus, which retain the gills throughout life. The limbs were in the form of paddles; the teeth showed a labyrinthine structure, a character shared by the devonian ganoids, and more markedly by the Labyrinthodons which followed them. The Archegosaurus became extinct at the end of the carboniferous period, when its place was taken by the closely allied Labyrinthodon, first discovered by its footprints, many of which, under the name of the Cheirotherium, have been found in our own neighbourhood. The Labyrinthodon still retained the supplementary

plates, but the vertebræ were well ossified, and were bi-concave, like those of fishes; the digits were never more than five, an approach to the true reptile; the position of the teeth is the same as in batrachians, but they resembled the long-tailed newts and salamanders more than the short-tailed batrachians, though generally represented as greatly magnified frogs, the much greater size of the hind than fore limb being the point of greatest resemblance. The structure of the teeth gave the name to the order which became extinct at the summit of the Trias.

The Neusticosaurus, from the Triassic rock near Stuttgart, described by Professor Seeley, paves the way for the Plesiosaurus, as it possessed a similar long neck and similar paddles on the fore limbs, but the hind limbs were adapted for progression on land.

The Ichthyosaurus still retained the supplementary piscine plates and the bi-concave vertebræ of the Labyrinthodon. The vertebræ, like those of its predecessors, were probably connected by an elastic capsule containing fluid, a character found in parennibranchiate batrachians. The eyes were very large, in some specimens 20 inches in diameter, and defended by a ring of sclerotic plates; the neck was very short, the tail long and compressed from side to side, and probably carried a caudal fin placed perpendicularly. This structure would enable it to live in deep water, the large eyes and protecting plates enabling it to dive to great depths and utilise the small amount of light which penetrated to its hunting place far below the surface.

The Plesiosaurus is generally associated with the above. It makes a nearer approach to the existing reptiles; the supplementary plates are wanting; the teeth were implanted in distinct sockets, as in the crocodile; the digits forming paddles were never more than five, as was often the case in his contemporary, the Ichthyosaurus. The allied Pliosaur differed little from the above, except that the head and limbs were more massive and the neck much shorter. The above reptiles,

often classed together under the name of Enaliosaurs, became extinct, like so many mesozoic forms, at the end of the cretaceous period. Contemporary with them were the Pterosauria, which have been so recently described by one of our members that I would refer you to his paper.

The Deinosaurs which appear in the Trias are characterised by their strong limbs, each toe bearing a nail. They were first observed by their footprints, and were supposed to have been huge birds. The celebrated footprints of the Connecticut Valley show the tri-dactyle impressions with the order of the joints precisely as in existing birds, the inner toe having three joints, the middle four, and the outer five. It has been, however, discovered that the Deinosaurs possess exactly the same peculiarities, as well as others which were extremely bird like; the bones were hollow and contained air chambers, while in many the pelvic bones were similar to those of a bird in the embryonic state, while one recently described by Prof. Marsh, had the pelvic bones co-ossified like a bird's. The structure of the hind limbs show that they either permanently or temporarily walked on their hind legs, and were therefore capable of making the footprints found in the Connecticut sandstone. Prof. Marsh, on a re-examination of these footprints, concludes that none of them have been made by birds, although he believes that birds existed during the Triassic period to which they are referred. The number of genera into which the Deinosauria is divided is so great, and the characters displayed by them often so abnormal, that they deserve much fuller treatment than can be offered in a paper like the present. Some, like the Megalosaurus, were carnivorous, like their marine contemporaries, the Enaliosaurus, and their winged companions, the Pterosaurs; others were herbivorous, as the Cetiosaurus and Iguanodon.

Prof. Huxley places them in close relationship with birds, including both in the province Ornithoscelida; while Prof. Owen shows that they have affinities with the Elephant and Rhinoceros. The latter determination has received strong

confirmation by the discovery of the Ceratosauri, described by Prof. Marsh, a genus which carried a horn like the living Rhinoceros. Professors Huxley and Cope can, however, point to the pelvis, which, unlike any other reptile, had the pelvic bones co-ossified like all living and extinct birds, with the exception of the reptile-like Archœopteryx.

A bare reference is all that can be made to numerous other orders, such as the Dycinodons, destitute of teeth with the exception of two long tusks, and having a beak-like mouth; the Oudenodous, without a vestige of teeth; the Rhyncosaurus, equally destitute of teeth, and having a very bird-like head; the Galesaurus, which in its dentition differs from all other reptiles, and foreshadows that of the carnivorous mammals; and lastly, but by no means least, the huge Mosasaurus, with its snake-like body 70 or 80 feet in length, and loosely articulated lower jaw, which allowed the mouth to open to an enormous extent, as in existing snakes: it was allied to the Lizards, however, and not to the Snakes. This appears to have been the last appearance of the great mesozoic reptiles, and occurs in the Maestricht chalk, associated with Deinosaurian remains.

There are four orders of reptiles still living, viz., Chelonia (Tortoises and Turtles), Ophidia (Snakes), Lacertilia (Lizards) and Crocodilia or Crocodiles. Footprints, supposed to be of Turtles, are found in the Permian and Triassic rocks, but an undoubted carapace has been found in the Portland beds. They appear to have reached their highest development in the Eocene period, as Owen asserts that more species of the true Turtle have left their remains in the London clay, than are known to exist in the whole world, but all Eocene species are extinct.

The earliest occurrence of a Snake is the Palæophis of the Bracklesham beds, which was marine in its habits, the only well authenticated Sea-serpent. Poisonous Snakes are found in Miocene beds.

The oldest known true reptile, the Protorosaurus, from the Permian rocks, is generally referred to the Lizards, but its

dentition is more like that of a Crocodile, and in other respects it resembled the existing Monitors. Remains of undoubted Lizards are found in the middle oolite, and they reached their maximum size in the mosasaurus referred to above.

Many of the older reptiles, from the Trias upwards, exhibit characteristics of a Crocodilian type in combination with those of one or more of the other orders, as, for example, the Hyperodapedon above alluded to. Fine Crocodiles are found from the Lias upwards. They differ very slightly from existing species, except in the form of the vertebræ. In all existing Crocodiles, the vertebræ are united by a ball and socket kind of joint, the socket being in front, and the ball behind. They are, therefore, said to be Procœlian, or hollowed in front. Crocodiles of this type make their appearance in the Greensand of America, but do not appear in Europe till the Eocene period.

In the oldest Crocodiles, which occur in the Lias, the vertebræ were hollowed in front and behind, they are, therefore, called Amphicœlian. They became extinct in the Cretaceous period. In a third class, the vertebræ are hollowed behind and have the ball in front, exactly the reverse to existing Crocodiles. These are said to be Opisthocœlian, or hollowed behind. Their range is similar to that of the Amphicœlians.

Only three species of the Crocodile now exist, the Crocodile confined to Africa, the Alligator found in America, and the Gavial in India; it is interesting to note that all three are found together in the London clay.

The reptiles reached their highest development in Jurassic and Cretaceous times. The older forms showed a more generalized type, as shown by the Piscine characters of the Carboniferous and Triassic Archigosauria and Labyrinthodonts, the avian characters of the Pterosaurs, the avian and mammalian characters of the Deinosaurs, and the combination of crocodilian chelonian, and lacertion characters in others.

LIVERPOOL GEOLOGICAL ASSOCIATION.

JANUARY 16TH, 1886.

The fourth visit to the Museum was made this day, when Mr. William Narramore delivered a Lecture on the "Echinodermata."

FEBRUARY 1ST, 1886.

At the Ordinary Meeting, held this date at the Free Library, Mr. H. BRAMALL, M. Inst., C.E., President, in the chair, Mr. C. F. Webb was elected a member, and Mr. John K. Dale, 124, Islington, was proposed for membership.

DONATIONS.

"The Garner," Nos. 1, 2 and 3, *presented by Mr. A. Ramsey.* Transactions of Manchester Geological Society, vol. 18, parts 12 and 13, *presented by the Society.* "The North Atlantic as a Geological Basin," by T. Mellard Reade, F.G.S., *presented by the Author.* "The Fossil Reptilia of the Cretaceous formation," by Professor Owen, F.R.S., *presented by Mr. T. R. Connell.*

EXHIBITS.

Mr. G. W. Gray exhibited a fossil fish's tooth, which he had found inclosed in a mass of Iron Ore. Mr. T. S. Keyte exhibited some Crystals of Selenite arranged in stellate order, found in the Keuper Marl, in the railway cutting, near Lime Street Station. Mr. W. H. Read, Secretary of the Science Students' Association, exhibited a number of rock sections by the Micro-Lantern, which were described by Mr. I. E. George.

A Paper was then read by Mr. EDMUND DICKSON, on

MICRO-PHOTOGRAPHY, AN AID TO THE STUDY OF GEOLOGY,

Which was illustrated by a series of photographs of fossils, &c.

The following Paper was also read by Mr. H. C. BEASLEY, on

THE MICROSCOPIC EXAMINATION OF SOME LIMESTONES FROM CAERWYS, NORTH WALES.

In a paper, read by Mr. A. Norman Tate before this Association in December, 1883, he drew attention to the great variety shown by chemical analysis in the different beds of Limestone in one quarry, in the Carboniferous Limestone at Caerwys. Noting more particularly the different percentages of Carbonate of Magnesia found in them, it was suggested that it would be interesting to see if there was any noticeable difference in their microscopic structure. Mr. Tate kindly supplied me with about twenty pieces from as many different beds, with the proportion of Carbonate of Lime and Carbonate of Magnesia each contained.

Unfortunately, shortly after I began their examination, I was obliged to give up microscopic work, and, as I have little hope, at any rate at present, of being able to resume it, I must beg you to pardon my bringing such a very slight and imperfect report before the Association, but I hope some member may be induced to carry on the investigation.

I will first read over some short notes of the appearance under the microscope of the specimens, about a dozen in all, that I have examined, together with the percentages of Lime and Magnesia.

No. 1.

Carbonate of Lime	96·80.
Carbonate of Magnesia	0·90.

Full of very perfect foraminifera.

No. 2.

Carbonate of Lime	54·40.
Carbonate of Magnesia	19·00.

Very finely crystalline. No trace of fossils.

No. 3.

Carbonate of Lime	95·60.
Carbonate of Magnesia	0·87.

A crystalline matrix; in places where less crystalline, it contains a good many micro-fossils.

No. 4.

Carbonate of Lime.............................. 55·10.
Carbonate of Magnesia.......................... 18·52.

Finely crystalline (but of a somewhat browner colour than No. 2). No trace of fossils.

No. 5.

Carbonate of Lime.............................. 95·70.
Carbonate of Magnesia.......................... 1·02.

Full of a great variety of perfect foraminifera.

No. 7.

Carbonate of Lime.............................. 91·20.
Carbonate of Magnesia.......................... 2·75.

Finely crystalline. No trace of fossils.

No. 10.

Carbonate of Lime.............................. 94·25.
Carbonate of Magnesia.......................... 2·75.

Full of very perfect foraminifera of several species. Some spicules and fragments of larger fossils.

No. 11.

Carbonate of Lime.............................. 56·25.
Carbonate of Magnesia.......................... 19·00.

In a somewhat earthy matrix there are patches of minute, clear, sharp crystals filling up spaces, some rectilinear, and others apparently formerly occupied by organic remains.

No. 12.

Carbonate of Lime.............................. 92·50.
Carbonate of Magnesia.......................... 1·50.

Full of foraminifera, but the matrix is not so purely crystalline as most of the others.

No. 13.

Carbonate of Lime.............................. 74·75.
Carbonate of Magnesia.......................... 19·00.

Mostly full of micro-fossils, with fragments of larger ones, but there are irregular patches of minute crystals of a brownish tint like No. 4.

Nos. 8 and 9,

Which were not analysed, were also found to be full of organisms.

It will at once be seen that the observations are far too incomplete to allow of any generalisation being based upon them. My first enquiry was as to the preservation of organic remains, and at first it seemed clear, as might have been expected, that where there was only a very small percentage of Carbonate of Magnesia, the micro-fossils were abundant, and although No. 7, with 2¾ per cent. of Carbonate of Magnesia, being finely crystalline and free from micro-fossils, threw some doubt on it, it was when I reached No. 13, with 19 per cent. of Carbonate of Magnesia, and found it full of organisms, that the assumption was found to be incorrect. It is to be observed that the three other samples, Nos. 2, 4 and 11, which contain about the same percentage of Carbonate of Magnesia, contain a much smaller percentage of Carbonate of Lime, viz., about 55 per cent., whereas No. 13 contains nearly 75 per cent. Carbonate of Lime, being composed almost entirely of Carbonates of Lime and Magnesia.

I think it is very probable that the same specimens of rock may be differently constituted in different parts, as I have found that not only do the sections cut from the same specimen vary, but the same section varies in different parts. I have roughly polished five different specimens, and on some there are traces of patches of more crystalline structure in places than elsewhere. But, as I said before, we have too little basis at present to serve any good purpose for discussion, and I should not have presumed to waste the time of the Association, except with the hope that some one else would take up the investigation, and I shall be very glad to place at their disposal the few sections I have prepared. It is a source of much disappointment to me that I have not been able to carry it out. I should very much like to see the quarry, or, at any rate, learn the relation the several beds, as numbered, bear to each other; whether they are in close proximity, or separ-

ated by any thickness of more argillaceous or impermeable beds; whether the strata are much disturbed; and whether there is any intrusion of igneous rock in the neighbourhood.

The whole subject is well worth investigation; and, as we have had the chemical part of it so ably carried out, I do trust that some one will take up the microscopic, and if, added to this, we could have an accurate description of the quarry itself, a very solid and useful piece of work would have been done, and one that could not fail to throw great light on some of the operations of nature that are at present very obscure.

LIVERPOOL GEOLOGICAL ASSOCIATION.

FEBRUARY 13TH, 1886.

The fifth visit to the Museum was made this day, when the Secretary, Mr. D. Clague, took the Sponges as the subject for study, noting their biological character and geological range in time.

MARCH 1ST, 1886.

At the Ordinary Meeting, held this date at the Free Library, Mr. C. E. MILES, Vice-President, in the chair, Mr. John K. Dale was elected a member. The attendance being small owing to the severe weather, the meeting was adjourned until Monday, March 8th, when the chair was occupied by the President, Mr. H. BRAMALL, M. Inst. C.E. Mr. John A. Gray, 36, Alfred Street, was proposed for membership.

The following Paper was read by Mr. T. S. HUNT, on

GEOLOGICAL NOTES FROM SWITZERLAND,

Illustrated by a series of photographic views of Alpine scenery, exhibited with oxy-hydrogen Lantern by Mr. James Lahy.

The mountains of Switzerland are, according to their elevation, generally divided into three sections, being designated the Higher, Middle or Lower Alps. Of this lower range, and constituting part of what is termed the Swiss Hill Country, we have the Righi, a group of mountains about twenty-five miles in circumference, at the base of which lies the Lake of Lucerne. The Righi is chiefly composed of a conglomerate of rounded limestone of an unusually large size, mixed with flint pebbles, the matrix being formed of a calcareous cement. This conglomerate is interstratified with layers of sand, which, by exposure to the elements, become disintegrated, and therefore unable to support their superincumbent strata, give rise to the various landslips for which the Righi is famed. Several instances of this can be seen on different parts of tho mountain.

On the path leading up from Weggis to the summit at a place known as the Felsenthor, two huge masses of conglomerate have fallen down, and, resting on a third, form a natural arch of imposing dimensions. The most disastrous landslip which has occurred in this locality took place at Goldau in the year 1806, when a tremendous mass of rock, upwards of two miles in length, 1000 feet in breadth, and over 100 feet in thickness, was undermined by the heavy rains and precipitated 3000 feet into the valley below, filling up one-fourth of the Lake of Lowerz, and burying four villages, with most of their inhabitants, in its descent. The Lake of Lucerne presents several features of geological interest, and its beautiful shores, fringed with the vine and the olive, offer many attractions. Several of its bays have been materially affected by alluvial deposits carried down by the adjacent torrents, the Alpnachsee, lying at the base of Pilatus, having been considerably narrowed through this agency. This phenomenon may be observed on several other of the Swiss lakes, more particularly on the Lake of Geneva, the area of which has been reduced to a very large extent by the debris carried down and deposited by the Rhone, the water of which, heavily charged with detritus, flows into the lake near Villeneuve. There is abundant proof that all the land lying between Bex and the present margin of the lake, ten miles away, was at one time occupied by the water of Geneva. A similar deposit may also be noted between the lakes of Brienz and Thun. Doubtless at one time these two lakes were united, and formed one sheet of water some twenty miles long and upwards of 2000 feet in depth. They are now separated by a narrow neck of land, composed of glacial deposit which has been carried down from the surrounding mountains, and which forms the low level plain on which the fine town of Interlaken has been built. A walk over the Brunig Pass from Alpnach, and along the wild glacier-ploughed Hasli-Thal to Meiringen in the Bernese Oberland, will amply repay the geologist. The moraines covering the bottom of the Hasli-Thal, and the river of snow-water which

rushes along the whole length of the valley with great impetuosity, are very interesting. Near Meiringen this river has been converted into a broad canal in order to keep the water under control, for at certain seasons of the year the stream, swollen in volume by the melting of the snow, frequently overflowed its banks, covering the whole district with mud and other debris, thus causing great devastation, extensive traces of which still remain. Continuing on through Meiringen, on the Grimsel route, over a country besprinkled with erratic blocks of granite, in a few hours the Handeck Fall is reached. This magnificent fall, which, with the exception of the Falls of the Tosa, is the most imposing in the Alps, exhibits, in a most striking manner, the cutting power of water and its denuding influence on the surrounding rocks, the abyss into which the water is precipitated being smoothed and polished in a remarkable manner by the boulders and stones which are carried irresistibly forward by the velocity of the stream which falls in an almost unbroken column from a height of 250 feet. The rocks round this region are of granitic formation, and are all more or less rounded and polished by glacial friction. Another fine waterfall near Meiringen is the double cascade of the Reichenbach, where the mechanical effect of running water and its eroding properties can also be studied under the most favourable circumstances. Beyond this cascade, and following the course of the stream up the valley, the Rosenlaui glacier is reached. This glacier lies imbedded between the Engelhorn and the Wellhorn, and although somewhat inferior in point of size, it forms a beautiful object, the ice being singularly clear and free from moraine matter, a fact which is probably due to the surrounding rock—black limestone—being of such a hard and indestructible nature. Where the formation is softer and more friable the glacier is not so pure, but presents a dirty appearance, which is caused by the detritus falling upon it and mixing with its ice. This is very noticeable in the case of the Grindlewald glacier, as seen from the Scheideck Pass.

An artificial cavern has been cut in this glacier, and on peering through the almost transparent walls forming the passage leading from the foot of the glacier to the cavern beyond, a fair sprinkling of angular stones and pebbles can be seen, mixed up in an inseparable mass with the ice. Immense blocks of gneiss, all more or less grooved and striated, form the terminal moraine, which can be traced down the valley for a considerable distance. About thirty yards away from the foot of the glacier I noticed a large mound of a different kind of rock altogether to the adjacent formation, which is gneiss or granite, interstratified with Jurassic limestone. This mound is composed of a slaty or shaly material, and has evidently been transported by the ice, and deposited in its present position as a moraine, long before the glacier had receded so far back as we now find it. These moraines are frequently found far away from any existing glacier, just as we find traces of them at the present day in several parts of the English Lake District and also in North Wales. The Rhone glacier, which is about fifteen miles long, is the largest in Switzerland, although only a remnant of what it was in bygone ages, when its ice not only occupied the valley of the Rhone, but also scooped out and filled the basin of the Lake of Geneva, covering a space some hundreds of miles in length and some thousands of feet in thickness. The valley is now full of marshy and malarious swamps, through which the Rhone winds its long tortuous course, whilst grapes, figs and pomegranates grow on its banks, and flourish with great luxuriance in the hot stifling atmosphere, presenting at once a marked contrast to the state of things that existed during the glacial epoch. The Rhone glacier has gradually receded up to its present position, and is imperceptibly but surely growing smaller and more insignificant every year, and in the course of time there will be nothing left beyond the perched stones and erratic blocks to indicate that ice at one period formed such an important feature in the landscape. A stream of water is the invariable outlet of every glacier I have seen,

and these streams are always muddy and charged with what Professor Ramsay calls the "flour of rocks," which is produced by the friction of the ice working over its rocky bed. Perhaps the most comprehensive view to be had of the glacier domain of Switzerland is to be obtained at Zermatt, from the summit of the Gornergrat, a rocky ridge rising from the tableland of the Riffelberg to an altitude of over 10,000 feet. The view from this summit is one of great magnificence, as it commands the whole of the Monte-Rosa chain, and the spectator, entirely surrounded by snow peaks and glaciers, cannot fail but be impressed with the grandeur of the panorama. Looking in a southerly direction all the giant peaks of Monte Rosa, the Lyskamm, the Breithorn, and the twin peaks of Castor and Pollux are quite near displayed to the gaze, whilst below and in the immediate foreground lies the Gorner glacier, with upwards of a dozen other glaciers emanating from the snowy wastes, which constitute the higher parts of the mountains. Looking from this elevation in another direction the peerless Weisshorn (14,800 feet), sheathed in ice almost from base to summit, presents a fine appearance; and a superb view is also obtained of the stupendous precipices of the Matterhorn, which appear to overhang the valley and the glaciers below. There is probably no better object to be found to illustrate the geological theory of degradation and disintegration than this mountain, whose crags and ridges, denuded and weathered into all kinds of weird forms, bear witness to the force of the atmosphere, and the heaps of debris and rubbish which lie all round its base testify to the power of the torrent and the avalanche. Owing to the precipitous nature of this isolated toothlike peak, little or no ice ever rests on its face, and during the day, when the sun exerts its full power, the accumulated snow comes thundering down on to the glaciers below with great uproar, carrying away any loose debris it may meet with in its descent, thus gradually effecting the degradation of the whole mass. A similar sight may be witnessed at various points among the mountains, especially on the Jung-

frau at midday, when hundreds of tons of ice fall in the shape of avalanches. The base of the Matterhorn is composed of gneiss and mica slate, the summit being formed of green slate, as Giordano has pointed out. The debris of several immense landslips can be seen in the St. Nicholas valley leading from Zermatt, and at its lower end, near Visp, the effects of several shocks of earthquake can also be observed. Near Vernayez, a sombre ravine, known as the Gorge-du-Trient, is well worth inspection. The bare rocks, which constitute the walls of this interesting natural formation, are upwards of 400 feet in height, and at different points approach each other so closely as to almost shut out the light of day. The gorge is eight miles in length, and the stream of water which flows through it is forty feet deep. This gorge, and the one at Pfafers (where the water, strongly impregnated with carbonate of lime, chloride of sodium and magnesia, comes bubbling up at a temperature of 100°) are perhaps the most curious spots in the Alps. Near Martigny some fine errratic blocks of stone claim attention. Some of these are accounted for by the Dranse torrent, which was caused by a prodigious fall of snow and ice in the upper part of the mountain, damming up the water of the Dranse until they formed a lake upwards of 700 feet long and some hundreds of feet in depth. This increasing volume of water at length proved too great a strain for its mighty barrier to withstand, and the dyke bursting, the water, charged with rocks, trees, houses and other debris, escaped, sweeping all before it in its disastrous career. Thus these mountain torrents often prove more powerful agents of destruction than the avalanche, desolating and devastating whole districts which the avalanche cannot reach or operate upon. In a grove of chesnut trees near Monthey, and about 1500 feet above sea level, another group of erratics is met with, one of which is of enormous size, and said to contain over 60,000 cubic feet of stone. Another block, much larger than the Bowder stone in Borrowdale, is curiously balanced on a point but a few inches in area. One of the finest and

most singular of these erratics, however, is to be found in the Canton of Neuchatel, where a gigantic block of fine grained granite—known as the Pierre-a-Bot—measuring 50 feet by 40 feet by 20 feet, rests on the limestone formation of the Jura. The walk over the Gemmi Pass, from Kandersteg to Leuk, forms another interesting excursion. The first portion of the route leads through a dense pine forest, but on rising higher most of the vegetation is left behind, and the path leads through a stony wilderness, consisting of gigantic blocks of limestone and the remains of several old landslips thrown down in chaotic confusion and covered with patches of snow. Stupendous walls and needles of bare rock, weathered into all sorts of fantastic shapes, shoot up far into the sky, whilst the Dauben See, a lake of mud, usually frozen over for seven months in the year, and the huge moraines and glaciers with which it is surrounded, combine to make one of the most sublime scenes to be met with in Switzerland. At the summit of the Gemmi (7550 feet) the traveller stands on the brink of a precipice of limestone upwards of 2000 feet in height, down whose almost perpendicular face the path leading to the valley below has been skilfully cut out of the living rock. Near Kandersteg, a small lake or tarn, known as the Blaue See, and remarkable for its brilliant colouring, possesses several interesting points. The rocks all round its vicinity have been upheaved by some mighty convulsion of nature, and the bed of the lake offers what appeared to me to be a very good example of a dislocated lake basin. On rowing over the surface of the lake, and looking through the singularly clear water, the bottom can be distinctly seen, and it looks for all the world like a vast inundated stone quarry, the banks being perfectly sheer and precipitous. The intense blue colour of the water is in itself peculiar, all the other Swiss lakes I am familiar with, with the exception of Geneva, being of a greenish tint. The Lago Maggiore, on the Italian side of the Alps, however, possesses the two colours, the northern arm being green, whilst at the southern end it is a deep blue.

The mountains round the village of Kandersteg are in many places split asunder into deep ravines, immense jagged chasms, which form walls and precipices of rock of colossal proportions. One of the most profound of these fissures is the Gastern Thal, where the crystalline and sedimentary formations are most strikingly seen. This valley is entered through a narrow gorge, which opens out into a vast rocky amphitheatre, where the strata, lying in great folds strangely contorted, can be closely examined. Having been caught in a terrific thunder-storm in this valley, I witnessed a cannonade of rock weighing some tons fall from the topmost crags of the mountain above to the floor of the valley, a distance of fully 3000 feet. The disintegrating force of this fall, which was evidently the result of the lightning, was most impressive, and it illustrated in a most forcible manner the way in which these apparently eternal mountains are being gradually torn and levelled down. The Lake of Geneva forms a fine object for studying the theory of glaciation as expounded by Professor Ramsay, and a visit to its shores, or a sail over its clear blue waters, will be found most interesting and compensating. Between Cully and Meillerie the lake is over 1000 feet in depth, but from this point to the efflux of the Rhone, the water gradually shoals off to almost nothing, the somewhat contracted part of the lake between Nyon and Geneva being particularly shallow in parts. These facts, and the distinct traces of glaciation to be met with all round, fully bear out Professor Ramsay's learned theory with regard to the formation of this beautiful lake, which is the largest in Switzerland, and whose waters cover an area of 225 square miles. Before closing these short and somewhat disconnected notes, I should call attention to the magnificent collection of minerals contained in the Mineralogical Museum at Bern. Some very fine crystals found at the Tiefengletcher a few years ago will be found in one of the cases. One of these unique specimens weighs upwards of 290 lbs., and several of the others exceed 200 lbs.

LIVERPOOL GEOLOGICAL ASSOCIATION.

MARCH 13TH, 1886.

The sixth and last visit of the season was made to the Museum this day, when Professor W. A. Herdman, D.Sc. of University College, gave a biological demonstration on the Limulus, showing its relation to, and divergence from, the crustacean form.

APRIL 5TH, 1886.

At the Ordinary Meeting held this date, at the Free Library, Mr. H. BRAMALL, M. Inst. C.E., President in the chair, Mr. John A. Gray was elected a member. The following were proposed for membership:—Miss Selina E. Ranford, 25, St. Georges Road, Mr. C. T. Mitchell, The College School, Huyton.

DONATIONS.

Transactions of Manchester Geological Society, vol. 18, parts 14, 15 and 16; Proceedings of the Geologists' Association, London, vol. 9, No. 4; Transactions of the Liverpool Engineering Society, vol. 3; Annual Report of Yorkshire Philosophical Society for 1885; 33rd Annual Report of the Free Public Library, Liverpool. *Presented by the respective Societies.*

An Address was given by Mr. Hugh F. Hall, F.G.S., on

WORK IN THE BOULDER CLAY.

EASTER MONDAY, APRIL 26TH, 1886.

The first Field Meeting of the season was held at Broxton this day. In a wood near Broxton Hall the denuding action of vegetation was well exhibited in a section of Bunter sandstone, which was penetrated by tree roots and rootlets, and broken up by their growth. Attention was drawn to the great

escarpment of Trias sandstone which overlooks the Dee Valley, and some time was spent in studying the ruins of an ancient encampment on the top of Larkton Hill. A visit was also made to the copper mines of the district, and specimens of Zenorite (black oxide of copper) and Cupreous sandstone were obtained.

MAY 3RD, 1886.

At the Ordinary Meeting, held this date at the Free Library, Mr. I. E. GEORGE in the chair, Miss S. E. Ranford and Mr. C. T. Mitchell were elected members, and Mr. James Dodd, 2, Union Terrace, Egremont, was proposed for membership.

The following Paper was read by Mr. H. ROBSON, B.Sc., of Wesley College, Sheffield, on

CARBONIC ACID AND ITS WORK IN NATURE.

I have now to ask your kind indulgence on behalf of an imperfect attempt to summarize some of the manifold and important tasks executed by carbonic acid in the economy of the earth. In their exact fulfilment it may be fairly said that we have one of the many conditions (all of them indispensable) of the continuance of life in the world.

When man contrives a tool, he is satisfied if it will do one special thing reasonably well, but the tools which the Almighty Master of nature has created to do His work in the universe impress us with the multifarious and diverse character of their duties not less than with the unerring precision and absolute completeness with which these duties are discharged. Now I cannot help thinking that it is most useful to obtain as general a view of the functions of each natural agent as possible, that is, to study its effects as a whole, and not merely piecemeal, under the different sciences which take cognizance of them; to bring together, in short, the work under the headings of the tools, in addition to the ordinary practice of bringing together partial accounts of various tools under the heading of some work which they assist one another in performing. If my present attempt in this direction will induce others more com-

petent than myself to take up the idea, my chief object in writing this paper will have been fulfilled.

Although there is no starting point in the mazy wanderings which the carbon-atoms are perpetually engaged in, through air, water, solid stone, or animal or vegetable tissues, yet we must necessarily make a beginning by fixing on some arbitrary point which we may regard as a terminus. For this we will take the evolution of carbonic acid into the air.

Carbonic acid is emitted into the atmosphere by ordinary combustion, as well as by respiration and the kindred process of putrefaction. Much of it also which has done work is returned to the air by evaporation from the sea. The normal proportion of carbonic acid in the air is about 1 volume in 2500, but in rooms or other enclosed inhabited spaces the quantity is often much greater. This brings me to the first function of carbonic acid which I wish to bring under your notice. I have already said that animal respiration pours carbonic acid into the air, but with the carbonic acid which results from perfect putrefaction, and which is only negatively injurious to life, the expired breath contains substances which are the result of less perfect decomposition, and which are septic, that is direct poisons. It is found by experience that the amount of carbonic acid in the air, which is readily estimated with accuracy, is a test of the amount of these septic bodies present, which cannot possibly be measured directly. It is found that air which has been vitiated by respiration so as to contain anything over 1 in 1000 vols. of carbonic acid is injurious to health, although an artificial mixture of 1000 vols. of air with 1 of pure carbonic acid has no such effect.

The carbonic acid in the air is one of the chief articles of food used by plants. Under the influence of sunlight the green parts of plants absorb carbonic acid, working up the carbon into their tissues, and returning the oxygen, which they do not want, as they get all they need of that element from water, into the air by an excretory process. Anyone who will call to mind the vast preponderance of green over all

other kinds of tissue in the vegetable kingdom, will have no difficulty in seeing on what a huge scale this second duty of carbonic acid is being discharged.

We now come to that part of the work of carbonic acid which has a more purely geological interest; I, of course, refer to its enormous efficiency as an agent of denudation. It so happens that carbonic acid is soluble in water, not, it is true, to the great extent that some gases are, but still soluble; hence it is swept out of the air by rain. Whenever this water, containing carbonic acid gathered from the air, and often additional quantities found in the soil, and generated therein by the putrefaction of vegetable and animal matter, comes into contact with rocks, it exerts upon them a solvent action which pure water is quite unable to effect. Limestone is dissolved away bodily by water containing carbonic acid. Sometimes the water loses its carbonic acid near the place where the solution of the limestone took place, and a petrifying spring results, but by far the greatest proportion of the dissolved limestone is carried by rivers to the sea. Rocks consisting of silicates, although not dissolved *en masse* like limestones, are quite as effectually acted on by carbonic acid. That gas slowly displaces the silicic acid from its salts, converting them into carbonates, soluble in water alone or in water containing carbonic acid. A large portion of the rock is thus removed, and what is left is mostly incoherent sand. One would have thought that sandstones, which consist in great part of free silica, almost the only rock-forming mineral unassailable by carbonic acid, would be safe; but in many cases the cement which binds the particles of silica together to form the stone is calcareous or ferruginous, and is readily attacked by carbonic acid. Hence the rock becomes disintegrated.

Sooner or later the carbonic acid, through the intermediary of rivers, carries the mineral matter which it has dissolved into the sea, and there holds it in a fit state for hosts of marine animals, which seize upon it and make from it all kinds of

beautiful and elaborate skeletons, which, when the animals have no further need of them, sink to the bottom, and help to build up some future continent just in the same way as so much of the dry land which we have now has been constructed.

I have with some difficulty restrained myself from going more into detail, and from digressing into collateral matters, but I think that I must not omit to call your attention to the wonderful provision made for securing an inexhaustible supply of the subject of this paper. The carbonic acid which has worked at denudation is restored to the air by evaporation, while that which has fed plants is returned either by the putrefaction of the plants after death, or by the respiration of animals which have fed on them. And when one burns a piece of coal, one restores to the air carbonic acid removed from it millions of years ago.

To sum up: Without carbonic acid there could be no plants. If that were so, neither human beings nor any other animals would have any food, for the food of every animal is vegetables or the flesh of vegetable-eating animals.

Without carbonic acid denudation and all its beneficent results, the formation of soil, the exposure of valuable but deeply-seated rocks, the supply to marine animals of the mineral matter necessary for their well-being, the provision of new land to take the place of what is being destroyed, and lastly, but not least, the production of beautiful scenery, would be checked to an extent which we have no means of estimating. Some of them would doubtless entirely disappear.

To afford us means of testing the purity of the vital fluid which we breathe, to feed plants, and through them ourselves and all other animals; by carving the earth's crust to minister to man's wants, to gratify his sight, and to ennoble his thoughts, to give to sea-animals their shells, and to help to make new land, these, then, are the vast, and one might have thought inconsistent tasks of one of the many agents, all equally important, which God has appointed to serve His purpose of benefiting His creatures.

LIVERPOOL GEOLOGICAL ASSOCIATION.

JUNE 7TH, 1886.

At the Ordinary Meeting, held this date at the Free Library, Mr. H. BRAMALL, M. Inst. C.E., President in the chair, Mr. James Dodd was elected a member.

DONATIONS.

Transactions of Manchester Geological Society, vol. 18, parts 17, 18 and 19; Transactions of Mining Association and Institute of Cornwall, vol. 1, part 2; *presented by the respective Societies.* Book of Great Sea Dragons, by T. Hawkins; *presented by Mr. T. R. Connell.*

A communicated Paper, of which the following is an abstract, was read by the Secretary, on

THE BRONZE AGE.

The accepted division of pre-historic time, into stone, bronze, and iron periods, was first made by Lucretius (born about 92 B.C.), and it would be curious to know how he arrived at the idea, at so early an age. It was not, however, until 1848, that these views were clearly established by Mr. J. C. Thomsen, a Danish antiquary, after having investigated the archæological remains of his own country.

In Denmark, in the lower peat bogs, a deposit varying in thickness from 20 to 30 feet, weapons of stone, now referred to the Neolithic or new stone age, accompany trunks of the Scotch fir. This tree does not now grow in Denmark, and has never done so in historic times. In the higher portion weapons of bronze are found, with the oak and acorns. Now it is known that the oak itself became scarce, and was at later times almost supplanted by the beech, a tree that now flourishes luxuriantly in Denmark. At the close of this later period tools of iron abounded, and gradually superseded those

of bronze. So we see that the evidence amounts to demonstration; and there is every reason to believe that it was the same elsewhere in Europe.

WHO THE BRONZE PEOPLE WERE.—Thanks to modern research we know that they were Celts, and that they came from Central Asia. This name is, it is said, a Greek term for foreigner. The Celts or Gaels belong to the greatest of the three families of human speech, the Aryan or Indo-European, and were the first of those peoples to emigrate to Europe. We don't know when this emigration took place, but it must have been some thousands of years before the Christian Era. Their earliest known home was the high table-land of Central Asia, near to the sources of the Oxus and Jaxterzes. Prof. Max Muller says—"There was a time when the ancestors of the Celts, the Germans, the Greeks and Italians, the Persians and Hindoos, were living together beneath the same roof."

LANGUAGE.—The language spoken by the Celts has been divided into two groups, the Cymrie and Gaelic. The Cymrie includes the Welsh, Cornish and Breton. The Gaelic is divided into the Irish, Scotch and Manx.

PLACE IN TIME.—Dr. Evans believes that the English bronze period lasted about eight or ten centuries, beginning 1400 or 1200 B.C. As the civilization (such as it was!) advanced westwards very slowly, it would not be contemporary in the various countries of Europe; that of Switzerland (the famous Lake Dwellings) being probably the oldest; and the French and Scandinavian lasted, no doubt, longer than that of England. The Scanian bronze age came down to about the Christian Era.

OCCUPATION OF THE PEOPLE.—They were, no doubt, essentially warriors, farmers, and hunters. That they were highly skilled in warfare is certain, seeing that after a time they made themselves masters of a great part of Europe. Another great family of tribes nearly identical with themselves, the Belgæ (even greater warriors), followed them into Europe, and wrested from the Celts, Belgium, the greater part of

Gaul (France) and other countries; and crossed over into England, which the Celts had already occupied, and were in possession of the whole of it south of the Thames at the arrival of Cæsar 55 B.C. The people who opposed the great Roman general in Gaul were Celts as well as Belgæ, and as it took him no less than nine campaigns to subdue them, we can understand what their prowess amounted to. That the Irish are the descendants of the Celts (proper) is certain, and the identity of the Welsh and Cornish with the Belgæ, although a subject of much controversy, is very probable.

WEAPONS.—These were various, and many of them were highly ornamented and cast in different patterns. We may mention swords, daggers, spear-heads, axes, knives and halberds; thus anticipating modern warfare. Helmets, bucklers and shields were also employed. Bronze arrow-heads were rarely used, as flint served their purpose equally as well, and was a long way cheaper.

AGRICULTURE.—The Celts were well acquainted, too, with the arts of peace, as the somewhat abundant remains of the goat, sheep, ox and pig show; also the cultivated cereals, wheat, barley, rye; and flax. It is singular that the only bronze article used was the reaping hook or sickle, from which it would appear that, like the Greeks and Romans, they cut off merely the ears of the corn. They must, of course, have had other tools, and several antiquaries believe that stone was so employed, but it is much more likely that their harrows, ploughs, &c., were rudely constructed from wood. Of bronze articles used for various purposes, it is worth mentioning that they had chisels, gouges, hammers, awls, tongs, punches, adzes and fishing hooks.

HABITATIONS.—In Ireland, fortified villages and crannoges or island forts were the usual homes, of which thousands of the former still remain; but as few of these are found in England, it seems more probable that wooden structures (seeing that the country was well covered with forests at this time) were resorted to. Caves were rarely used.

Dress and Ornaments.—The bronze man, unlike his Neolithic predecessor, was acquainted with woollen homespuns. From barrow remains it would seem that woollen articles constituted largely the dress along with leather leggings and sandals; linen, no doubt, was used too. These people had an extraordinary taste for ornaments, as large varieties of breast-pins, bracelets, torques or collars, rings, finger rings and ear-rings show.

Religion.—We know hardly anything, for certain, about this subject, notwithstanding the volumes that have appeared, from time to time, about their priests the Druids. That the Druids were powerful, were soothsayers and magicians, and that they held periodically great festivals offering up sacrifices, (no doubt connected with sun worship) is very probable. That Stonehenge and Avebury are temples of the bronze age is clear, from the large number of tombs of this period that lie scattered around them. Great numbers of remains of stone circles are found all over the British Isles; that many of these mark the last resting places of bronze chieftains, and that many were temples as well as tombs, there is every reason to believe; but, unfortunately, the data available is very scanty.

Tombs.—That the Celts highly respected the remains of their mighty dead is certain, from the number and size of their tumuli. These consist of barrows (earth mounds) and cairns (stone heaps). The tumuli vary in size from a few feet to a miniature mountain, like Silbury Hill near Avebury, that covers ·5 acres and is 130 feet high. From the labour necessary to build them, it is concluded that the leading families were alone so honoured. Usually these barrows are really vaults. In some cases the bodies of infants alone are found in them. In shape they are usually round, others approach the oval, while some are oblong like those of the Neolithic times.

Burial Customs.—Inhumation and cremation were practised side by side. No rules appear to have been followed; sometimes the body was laid in a grave below the natural level

of the ground, sometimes on it. The body is very rarely laid on its back, but usually on its left or right side, the face being turned in an easterly or westerly direction; from this it is concluded that the time of day when the funeral took place is indicated, the face being turned toward the sun at the hour of burial. When the body was burnt it was not always laid in an urn, but sometimes where it had been cremated, and the mound raised over it. The vessels containing burnt bones (cinerary urns) vary in size from 5 inches to 3 feet, and are very often ornamented. This has been done by pointed sticks, the fingers, and twisted pieces of leather. No figures have, in any case, been found on them. In all instances they have been fashioned by hand.

Belief in a Future State.—The occurrence of what are called "drinking vessels," "incense cups" and "food vessels," many of which are beautifully made, and weapons of various kinds along with the remains of the dead, is regarded as certain evidence that these people believed in a future life; that these articles were intended to hold food, and to assist them on the journey to Wallahalla—the Happy Hunting Ground. These vessels vary much in size, and from their porous and fragile nature it is clear that they were made expressly for the use of the respected dead.

LIVERPOOL GEOLOGICAL ASSOCIATION.

WHITMONDAY, JUNE 14TH, 1886.

A Field Meeting was held this day in the neighbourhood of Carnforth, under the guidance of Dr. C. Ricketts, F.G.S. In the course of the day's walk some interesting features of Glacial geology were studied; amongst others several cuttings through moraines near the sea level were examined, while on the hill tops were seen extensive and deeply glaciated surfaces, together with perched blocks. Visits were made to a mine where Hematite is being prepared for red paint, and to a quarry in the Carboniferous Limestone. where a thin seam of interbedded coal was found, and also numerous fossils. A sunken road, which led to the quarry, ran along the top of Troughbarrow Hill, and was found to be due to the erosion of a bed of shale from between vertical beds of Limestone. These beds were continued into the quarry, and afforded much interest in their examination. The return journey led through "Deepdale," a circular hollow of considerable depth and of supposed "swallow-hole" origin. The picturesque country traversed was full of geological interest, and the full enjoyment of the walk was only marred by the unfavourable state of the weather.

JULY 5TH, 1886.

At the Ordinary Meeting, held this date at the Free Library, Mr. H. Bramall, M. Inst., C.E., President, in the chair.

Mr. Josiah Thorp, 8, Gladstone Road, was proposed for membership.

DONATIONS.

Report of the Smithsonian Institute for 1884; Transactions of the London Geologists' Association for February,

1886; Annual Report of the Belfast Naturalists' Field Club, 1884-5, *presented by the respective Societies.*

EXHIBITS.

Specimens of Sandstone from Flaybrick Hill, coloured by Manganese and Iron, were exhibited by Mr. C. E. Miles, and specimens of Limestone, Shale, Arragonite and Hematite collected at Carnforth, were shown by Mr. I. E. George.

The following paper was read by Mr. Herbert Fox, on

STRONTIUM AND ITS MINERALS.

The following notes, though mainly collected from the works of other writers during the process of some investigation in which the author was engaged some months back, may yet be of service from their being here presented in a collective form.

The attention of the author was first directed to the subject by the reported discovery in the west of England of a large quantity of Celestine, and it was during the examination and analysis of samples of this mineral that he was met with a difficulty which has inspired the hope expressed above as to any use these notes may be. The difficulty was this, viz., the absence of any published text book giving both chemical and mineralogical information of the Strontium compound in anything like detail, and the necessity of consulting a comparatively large number of books in order to obtain what was really but a small amount of information.

Strontium, one of the metals of the alkaline earth group, and occupying the middle position between barium and calcium both in properties and atomic weight, derives its name from that of Strontia, a village in Argyllshire, in which the mineral Strontianite or carbonate of strontia was first found. This mineral was first mistaken for barium carbonate, but in 1790 Crawford suggested that it contained a peculiar earth, and this was confirmed by Hope in 1792, and independently by Klaproth a year later. The metal strontium was first obtained by Sir Humphrey Davy in 1808. It occurs chiefly as the sulphate

or celestine and the carbonate or strontianite, and exists in many specimens of arragonite and calcspar, and in limestone, marble, chalk, &c., although in these latter it is present only in very small traces.

A silicate is also known, and small quantities of strontium sulphate and strontium carbonate occur in solution in many brine springs, as well as in some mineral waters. It is also present in chalk waters, as, for example, the London Basin. It has been found in sea water, also in the ashes of *Fucus vesiculosus.*

Davy obtained the metal by the electrolysis of either the moistened hydroxide or of the chloride, but it is best prepared according to the method employed by Bunsen and Matthiessen.

A small porcelain crucible, with a porous cell placed in the middle of it, is filled with anhydrous strontium chloride, mixed with a little sal-ammoniac, the level of the salt in the cell being considerably higher than in the crucible. The negative pole consists of a very thin iron wire wound round a thicker one, and covered with a piece of tobacco pipe stem, so that only about one-sixteenth of an inch appears below. This is placed in the porous cell. The positive pole is an iron cylinder placed in the crucible round the porous cell. If the heat be regulated so that a crust forms in the cell, the metal collects under the crust without coming into contact with the oxygen of the air.

Strontium is a yellow metal somewhat harder than calcium and lead. It is malleable, and can be beaten out into a thin leaf. Its specific gravity is 2·5. It melts at a dull red heat, oxidises quickly on exposure to the air, burns brilliantly when heated in air or oxygen, and decomposes water violently.

The most important of the manufactured compounds of strontium, which are all, or nearly all, made from the native sulphate or carbonate, are :—

1st.—The *oxide* ($Sr\ O$), prepared by heating the nitrate to redness, or by exposing the carbonate, either alone or mixed with charcoal, to the strongest heat of a forge fire. It unites with water to form the *hydroxide* ($Sr\ (H\ O)_2$). This is now

being employed in the manufacture of sugar, for the recovery of sugar from molasses, in place of baryta.

2nd.—The *chloride* ($Sr\ Cl_2$) a soluble salt, obtained by dissolving the carbonate in hydrochloric acid. The commercial salt frequently contains chloride of calcium, from which it can be purified by re-crystallization.

3rd.—The *nitrate* ($Sr\ (NO_3)_2$) also soluble, which is largely used for pyrotechnic purposes, and which is obtained by dissolving the carbonate in warm dilute nitric acid.

The more important native compounds are:—

Celestine, or strontium sulphate, occurs in orthorhombic crystals, also fibrous and radiated masses, and often granular.

H. 3—3·5. G. 3·92—3·975. Lustre, vitreous, inclining to pearly; streak, white; colour, white, sometimes bluish, owing to presence of phosphate of iron; transparent, subtranslucent.

It is usually associated with sandstone or limestone, and occurs also in beds of gypsum, rock salts or clay, and is found associated with sulphur in volcanic regions.

It is found in quantity in Sicily, also in parts of Switzerland, Spain, France, and in many places in the United States.

It is insoluble in water and acid, and fuses under the blowpipe, colouring the flame red.

Baryto-celestine is a double sulphate of barium and strontium, containing about 25 per cent. of barium sulphate.

Strontianite, or strontium carbonate, occurs in orthorhombic crystals, also fibrous and granular.

H. 3·5—4. G. 3·6—3·7. Lustre, vitreous; colour variable, pale green, white, gray, yellow or brown; streak, white; transparent—translucent. Fracture, uneven, brittle. Before the blowpipe it swells up, fuses over the edges and colours the flame red. The assay shows an alkaline reaction after ignition. It is soluble in hydrochloric acid.

It occurs at Strontian, Argyllshire, in Yorkshire, at the Giants' Causeway, in the Hartz, Saxony, and in the United States.

Brewsterite is a triple silicate of barium, strontium and

aluminium, and possesses the composition H_4 (Ba Sr) Al_2 Si_6 $O_{18} + 3\, H_2O$.

As regards the detection and estimation of strontium, it colours the flame a most brilliant crimson. The spectrum consists of a number of bright lines, of which eight are especially characteristic, six in the red, one in the orange and one in the blue. By means of the spectroscope it is said that $\frac{6}{100,000}$ mgm. of strontium can be detected. To detect its presence in a mineral, the assay alone, or moistened with hydrochloric acid, is brought into the flame. If the strontium is supposed to be present in the form of a sulphate, the bead is held for a moment in the reducing flame and then moistened with hydrochloric acid, whereby the strontium sulphide, which has been formed, is converted into chloride.

Strontium can be separated from the metal by precipitation with ammonium carbonate. If calcium be present at the same time it may be detected by the addition of a solution of gypsum to the hydrochloric acid solution of the carbonate, which, in the presence of strontium, will become turbid after a short time.

The following process has been found by the writer to yield most satisfactory results, in the quantitative determination of strontium. After the separation of the iron and alumina, solution of ammonia, ammonium chloride and ammonium carbonate are added to the clear solution, when the barium strontium and calcium present are thrown down as carbonates. Dissolve these in hydrochloric acid, and precipitate again as sulphate. Digest the precipitated sulphates for twelve hours, with frequent stirring, at the common temperature, with a solution of ammonium carbonate, decant the fluid on to a filter, treat the residue repeatedly in the same way, wash finally with water and in the still moist precipitate, separate any undecomposed barium sulphate there may be, by means of cold dilute hydrochloric acid, from the carbonate of calcium and strontium formed; filter; boil down and add about fifty times the quantity of ammonium sulphate dissolved in four times its weight of water, and allow to stand for twelve hours; filter;

wash the precipitate which consists of strontium sulphate, together with a little strontium ammonium sulphate, with a concentrated solution of ammonium sulphate, until the washings remain clear on the addition of oxalate of ammonia. The precipitate is cautiously ignited, moistened with a little diluted sulphuric acid to convert any sulphide into sulphate, reignited and weighed.

LIVERPOOL GEOLOGICAL ASSOCIATION.

AUGUST 2ND, 1886.

A Field Meeting was held at Llangollen this day. Mr. Joseph Brown conducted the party over the Wenlock shale of Llangollen valley, across the old Red Sandstone cropping out at the foot of Eglwysyg Rocks, along the talus of the great escarpment of Carboniferous Limestone, and up to the summit of Cefn Fedw where the Carboniferous Limestone is capped by the Millstone Grit, studying the various zones in the Limestone which are marked by characteristic fossils. Mr. I. E. George pointed to the broad features of the surrounding country as illustrating various points of geological interest.

AUGUST 28TH, 1886.

A Field Meeting, conducted by Mr. C. E. Miles, was held at Dawpool, where sections of the Drift were studied in a walk along the shore from West Kirby.

SEPTEMBER 6TH, 1886.

At the Ordinary Meeting, held this date at the Free Library, Mr. C. E. MILES, Vice-President, in the chair, Mr. Josiah Thorp was elected a member, and Messrs. G. C. Beecham, 11, South Hunter Street, and W. C. Rowlands, were proposed as members. Messrs. John Morris and John K. Dale were elected Auditors.

DONATIONS.

Proceedings of Liverpool Naturalists' Field Club, 1885-6; Transactions of Manchester Geological Society, vol. 18, part 20; Transactions of Burnley Literary and Scientific Club, Vol. 3, 1885; Journal of Liverpool Polytechnic Society, two parts. *Presented by the respective Societies.*

The Chairman announced that the President, Mr. H. Bramall, had removed to Manchester, and would be unable in consequence to attend future meetings. A resolution was passed thanking Mr. Bramall for his past services.

The following Paper was read by Mr. W. H. Quilliam, B.A., on

GIBRALTAR.

To every Englishman the name of the historic rock, the key of the Mediterranean, must be familiar, and perhaps few other places can boast of so remarkable a history from almost prehistoric down to modern times. The "Mons Calpe" of the ancients, and one of the two Pillars of Hercules, the other "pillar" being "Mons Abyla" (Ape's Hill) in Africa.

Doubtless all of us have heard the legend with reference to these two mountains, which, according to both Strabo and Pliny is, that they were formerly united, and enclosing the Mediterranean at that point made that sea a vast inland lake; but that Hercules separated them and made a communication between the Mediterranean and the Atlantic seas, thus forming the present Straits of Gibraltar.

Looking at the old tradition as Geologists, we have ample evidence, by comparing the rocks composing the two "pillars," that they no doubt were formerly united; but that the Hercules that divided them and liberated the waters of the inland sea was doubtless one of those great volcanic disturbances that have played so prominent a part from time to time in altering the conformation and appearance of the crust of old Mother Earth.

The two "pillars" (Calpe and Abyla) are distant from each other about 14 miles; but the Straits themselves are only nine miles across from shore to shore. The Moors called the Straits Bab-ez-zakak, the "gate of the narrow passage."

Gibraltar itself may perhaps best be described as "a bold headland promontory, jutting insularly into the sea at the entrance of the Mediterranean."

It is divided by a mountainous ridge running almost due

north and south, and separating the rock into two unequal parts.

It is a peninsula of oblong form, running almost directly south in the direction of Africa, and is about 3 miles in length; its greatest breadth is three-quarters of a mile, and its total circumference about 7 miles. The acreage of Gibraltar, including the portion of the isthmus which connects the rock proper with the mainland, known as the "North front," is 1,266 acres, of which only between 21 and 22 acres (public property) are reserved as garden ground. Other spots, however, are under cultivation in both government quarters and private property; but the greater portion of the rock is incapable of cultivation.

As before mentioned, the rock is connected with the mainland by a low sandy isthmus known as the "neutral ground," nearly a mile long, and varying from 950 to 1,800 yards in breadth. This isthmus is evidently of comparatively recent formation. I found a few shells in it almost identical with the ones I picked up on the sea shores of Africa just across the Straits.

The northern side of the rock, which faces this isthmus, rises a perpendicular and unbroken cliff to the height of nearly 1,400 feet, terminating in a narrow plateau.

On this narrow plateau a powerful battery is now planted; but during the great siege of Gibraltar the guns of this battery, notwithstanding its great height, were frequently dismounted by the shells thrown into it by the enemy.

On the western side the slope of the rock is gradual, and it is on this side that the town is built; the eastern side, which faces the Mediterranean, is an inaccessible cliff, with a sharp slope of 45 degrees running nearly to the top, destitute of vegetation, and forming a series of dangerous rugged precipices, broken only in one spot by an immense bank of sand 450 feet in height, and known as the Catalan Sands, and lying unconformably against the rock under the Signal Station Hill. In height the rock is about 1,500 feet, and its crest is divided

into three points; at the north by Wolf's crag, 1,250 feet high, on which is situated the battery previously referred to; in the centre, the Upper Signal Station, 1,255 feet high; and at the south by the ruins of O'Hara's Tower on Sugar Loaf Hill, 1,408 feet high; the greatest height being at a point between the Signal Station and O'Hara's Tower.

It may be interesting to mention, that the sister mountain "Ape's Hill," on the opposite African shore, attains the height of 2,808 feet, and the nearest hill on the Spanish coast, "The Queen of Spain's Chair," 971 feet. (The peak of this latter hill is distant 6,866 yards from Wolf's Crag, the nearest point of the rock.)

The rock of Gibraltar is composed of compact limestone or dense grey marble, apparently of the Oolitic system, and varied by beds of red sandstone and fissures of osseous breccia. This last-mentioned somewhat resembles in character the "coral rag" of the Middle Oolite of this country, and also that found in the limestone rocks of Nice, Pisa, Antibes and Dalmatia, and is said to contain the bones of various animals; amongst others, claimed to have been discovered and enumerated by Cuvier, are the elephant, ox, deer, cave-bear, sheep, horse, ass, and even snakes. This statement, however, like many others, must be taken "cum grano salis." Personally, all I can vouch is, that, after several days' hard work amongst it, I discovered "none of these things;" perhaps, however, I was not born under a lucky planet. On the western side of the rock, and at the base of the precipice, which runs about half-way up the mountain, lies a sloping plain of stratified silicious sand, known locally as the "Red Sands," and on which the lower part of the town is built. On the eastern side are the famous Catalan Bay sands, which I have before mentioned. These beds slope outward against the eastern face of the rock at an angle of nearly 80 degrees, and appeared to me to be about the Upper Miocene period, and to correspond with the Faluns of Touraine or the Bolderberg strata of Belgium. During the great earthquake which destroyed Lisbon, these

sands sunk many feet, and large pieces of the rock became detached and rolled into the sea. The surface of Europa Point (to the South) is almost entirely composed of water-worn rock, and at the back, and 270 feet above the sea level, is an oyster bed.

The following extract from the "Geology of Gibraltar," by James Smith, F.G.S., published in 1844, will be doubtless interesting:—"There is no doubt that Gibraltar has undergone many movements of upheaval and depression, accompanied by violent ruptures of strata, land slips, and continual sea action. The beds of limestone must have been formed at the bottom of the sea during the secondary period, as is shown by the marine remains contained in them, in a position nearly horizontal, and they were tilted up by some force acting from below, most probably volcanic. This was the first period in the history of the rock, and in the second fresh beds were deposited round its base, which were again tilted up 19 degrees more than they were at first by a second upheaval. This movement, however, was only partial, and confined to the southern portion, and the rock was broken across, the line of fracture being plainly marked by the gap and ravines between Middle Hill and Rock Gun Height. During this epoch the Catalan Bay Sands were formed; the wasting action of the sea had formed a cliff and terrace, and on this beds of sand were deposited, sloping outward, and in one of the numerous changes of level to which the rock was subjected, the whole of these sands were lifted up. A third upheaval, still further south of Middle Hill, again tilted the beds in that part 19 degrees. The line of division is marked by an indentation to the south of Signal Station Hill. These successive and violent alterations have been instrumental in giving so irregular an outline to Gibraltar, the grand sentinel watch tower of the Mediterranean. Hence the Spanish names for it 'El Cuerpo' (The Corpse) and 'The Crouching Lion.' 'A guisa de Leon cuando se posa;' and these appearances can be easily traced, the former looking south, the latter north,"

It may be interesting to mention here, that constant experiments have been carried out in many parts of the rock proper for the discovery of springs of water, but all have hitherto been unsuccessful, and until the year 1868 the supply of water was entirely dependent on the rainfall; but in that year a boring succeeded in discovering fresh water on the North Front (part of the sandy isthmus I have before mentioned), and several wells have now been sunk, and the water from these is now pumped into the town into enormous tanks. The actual source of the water found at the North Front is a subject of controversy, but it is generally believed to be derived from two sources, the drainage of the opposite Spanish hills, the "Sierra de Carbonera," and the filtration of surface water through the large area of sand of the North Front and the Neutral ground. The depth of the clay which retains this water must be very near to the sea level, as towards the end of the summer the water pumped up is so mixed with sea-water as to render it scarcely useable.

As in all compact limestones, there are a number of caves and fissures in the rock, which can be divided into land and littoral or sea caves. The principal ones are "St. Michael's" (the largest), the three "Genista" and the "Judge's" Cave (among the land caves), and "St. Martin's," the "Poca Roca," "Fig-tree," and the "Monkey's," among the littoral caves.

The largest of these is "St. Michael's," the entrance to which is 1,100 feet above the sea level. According to tradition it derives its name from the similarity of its appearance to the cave in the mountain of "Gargano del Apulla," in which St. Michael is fabled to have appeared. The entrance is small, but shortly afterwards expands into a species of lofty hall, 220 feet long, 90 feet wide, and 70 feet high, supported by very fine stalactite pillars, some of them from 30 to 50 feet in height. Explorers have penetrated many hundreds of feet into this cave and have discovered a long series of smaller caves, but their actual extent is unknown. This cave

is described by Pomponius Mela, a geographer of the Augustan age, who writes:—"The mountain Calpe contains wonderful concavities, its western side is almost opened by a large cave, which may be penetrated far into the interior."

The "Monkey's" cave has also never been explored to its full extent. A legend is still believed by many inhabitants of the town that this cave runs into a subterranean passage which goes under the straits, and finds its exit in another cave in Ape's Hill, in Africa, and that it was through this subterrannean tunnel that the progenitors of the present monkeys who inhabit the rock managed to get there.

These monkeys, always associated with the Rock of Gibraltar, were in 1883, when I visited the place, but few in number, only twenty altogether, if I remember aright. They are of the Barbary Ape species, and may often be seen on the western side of the rock, particularly when a Levant wind is blowing; occasionally they rob the gardens, but, I was informed, they principally live on the sweet roots of the palmetto. When the water in the catch-pits on the rock is exhausted through the evaporation caused by the summer heats, they become very bold in their search for it. The men at the Signal Station take notice of their movements, and any youthful addition to their family is duly announced in the local newspaper.

In all the caves great quantities of partially fossilized remains, including human skulls, bones and teeth, with flint weapons and pottery, have been discovered; among them bones of goat, ox, ibex and other mammals; remains of birds, reptiles and fish; stone axes and daggers, armlets and anklets, worked bone needles, spoons and hair pins; flint knives and chips, querns, rulstones, charcoal, &c. In one cave it is said that the remains of no less than thirty-six persons were found.

In the course of some excavations above the Moorish Castle, a perfect human skeleton was also discovered, but the miners blew it into pieces.

The only metal articles found were a bronze fish hook,

probably of the Roman epoch, a plaque of Limoges work, doubtless, part of some military equipment, and two swords, with globular pommels, mounted with silver.

These caves have, therefore, evidently been used from time to time for different purposes, sometimes as habitations, other times as places of refuge or concealment, while others appear to have been used only as sepulchres.

It may be *apropos* to remark that in Tetuan on the African side, where the strata very much resembles that of the Rock of Gibraltar, I saw a number of small caves used by the inhabitants as work-shops. The stone principally used for building and paving purposes in the town of Gibraltar is taken from the rock in quarries at the base of the northern front of the mountain, the limestone there being of a particularly good and close quality; of course great care being taken that the stone is cut away so as to add, by scarping, to the impregnability of the rock.

For military purposes the rock has been tunnelled at a considerable height on the north and north-west faces of the mountain with two sets of galleries, the upper and lower, and the heavy ordnance mounted there commands the north front, the neutral ground, a portion of the bay, and the little Spanish town of Linea, which nestles at the base of the Queen of Spain's chair.

Our botanical friends will find the flora of Gibraltar rich and varied; there are 456 species of flowering plants and ferns indigenous, and 44 which are cultivated and introduced. One plant only is peculiar to the place, the *Iberis Gibralterica.*

There are but few animals on the rock. Rabbits are the most plentiful, foxes and badgers are also found; the monkeys I have already mentioned. In ancient times the wild boar and wolf were also inhabitants of the rock. Reptiles are numerous, chiefly lizards, centipedes and snakes, the latter of a non-venomous species. Eagles build their nests in the crags at the Signal Station, and several varieties of hawks are common. Wild pigeons breed abundantly in the caves at the

eastern side of the mountain, and a few wild partridges are to be found in the district called Europa flats.

The following extracts from an article entitled "Gibraltar described," which appeared in a work entitled "The Political Magazine and Literary Journal," published in 1781, will doubtless be found interesting.

"*Isthmus of Gibraltar.*—All the narrow neck of land which joins the rock of Gibraltar to the mainland, was once covered by the sea, as is plain from the shells the sand is full of, but in what age has not reached us. We can, even now, ascertain the height of the water at the head of the rock; where the sea has mined it into caverns and hollows, and discoloured it above 40 feet higher than the present level of the sands. It is clear that the sea has been gradually declining; the 'Devil's Tower' is built on a rock nine feet above the ground, which was once evidently washed by the waves. An old French book, written 400 years ago, treats at large of this decrease of the sea at Gibraltar.

Inhabitants of the Rock.—On viewing this hill, one would not imagine any living creature could exist upon it; yet a numerous species occupy the tops of the highest rocks, and are the true lords of the hill; for neither Moors, Spaniards nor English have ever been able to dispossess them. These inhabitants are monkeys. They are so little afraid of man, that they often declare war, and not long ago, they acted in so hostile a manner by throwing down such a number of stones on our miners at work, that they frequently forced them to leave off and retreat out of reach. Foxes and porcupines also inhabit the rock, and snakes are very numerous, but not venomous. The centipede is ten inches long, and is divided into forty joints, two claws to each, its head red, with feelers or horns an inch long, its mouth is armed with pincers with which it offends; its bite is venomous but not mortal."

The rock was doubtless known to, and perhaps visited by the Phœnicians, and is referred to and described by both Greek and Roman writers; but it probably was uninhabited

until the Moslem invasion of Spain, in A.D. 711, when the Moorish chief Tarik-Ibn-Zeyad, landed on the rock with an army of some 12,000 men, and from him it received its present name, Gibraltar, undoubtedly being a corruption of Gebal-Tarik (Arabic), "The Hill of Tarik."

To follow the history of the rock through its varying fortunes as it was taken and retaken from time to time, although an interesting study in itself, would not be exactly within our province as a geological society to trace, and therefore I will simply mention that on the 24th July, 1704, it was taken after a siege of only three days during the war of the Spanish Succession, by a squadron under the command of Sir George Rooke, and from that time to the present the "Union Jack of Old England" has waved triumphantly, though not unmolested, over this great fortress.

SEPTEMBER 10TH, 1886.

The final Field Meeting of the Session was held this day, jointly with the Liverpool Science Students' Association, the "Potatoe Delph" Colliery at Lea Green being visited. Attention was directed to a "squeeze," which is probably the filled up bed of a river that flowed through the fern brakes of carboniferous age. In another part of the workings, Lepidodendra were found in great profusion, the trunks being in some cases intact, while the finer twigs were interlaced on the roof of the cutting.

JOHN DONALD, PRINTER, 556, PRESCOT ROAD, OLD SWAN.